Flagstaff Watershed Protection Project

Soil and Water Specialist Report

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for:

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1.0 Introduction

This report is the specialist's report for soil and water resources relevant to the proposed Flagstaff Watershed Protection Project (FWPP). The purpose of this report is to provide detailed information and analysis regarding soils and watershed resources in order to support the conclusions in an Environmental Impact Statement (EIS). This report provides a brief description of the project; discusses key assumptions and methodologies used in the analysis; identifies existing inventories, monitoring, and research literature used in the analysis; describes desired conditions and site-specific resource conditions; identifies potential resource impacts and effects of the proposed action and alternatives; and recommends site specific mitigation measures to minimize or avoid negative effects.

Overview of Issues Addressed

The principal issue of concern to soils and water resources from the action alternatives is the increase in erosion and consequent impacts to water quality that may occur from implementation of proposed treatments. Other things being equal (i.e., soil texture, climate, and slope), rates of erosion are closely correlated with vegetative cover, and it is the disturbance of this vegetative cover that it most likely to cause post-treatment accelerated erosion.

2.0 Affected Environment

2.1 Existing Condition Assessment Methodology

Analysis of the existing condition of soils and water resources and the potential effects to these resources from the alternatives was accomplished through a review of peer-reviewed literature, reports from regulatory and land management agencies, existing resource inventories, field visits, and the professional judgment of the specialist(s). No sampling of soils and water quality was performed as part of this analysis. Information on the existing conditions of soils, springs, riparian areas, and wetlands is presented only for these resources which are found within the project area since proposed actions would likely only affect these resources that are within the project area. Information on the existing conditions of drainage areas and water quality is presented at the sub-watershed scale since proposed actions would potentially affect these resources at this scale.

This section describes the resource inventory sources, methodology, and analysis processes used to determine the existing conditions of soils and watershed resources.

2.1.1 Terrestrial Ecosystem Survey

The description of existing conditions of soil resources, including limitations associated with their management and land use activities, relies largely on information published in the Coconino National Forest (CNF), Terrestrial Ecosystem Survey (TES) (Miller, et. al. 1995).

A terrestrial ecosystem survey consists of the systematic examination, description, classification, and mapping of terrestrial ecosystems. TES delineates ecosystems into components and larger map units according to their climate, geology, soils, and potential natural vegetation. Components with similar appearance and attributes are grouped into map units. Map units with a single component are called consociations and those with two or more components are referred to as complexes, if the associated components are too intermingled or small to be shown at the TES map scale, or associations if the components can be shown separately but use and management does not justify separation.

Mapping of terrestrial ecosystems was initially done by stereoscopic examination of 1:24,000 aerial photographs with concurrent collection of general data, called observations, on soil classification, plant community, geology and geomorphology. More detailed site descriptions were developed from at least one 375 square meter field plot established at reference sites for each component of each map unit. The site descriptions include general setting information, lithology, stratigraphy, geomorphic classification, a complete soil pedon description, a listing of plant species occurring on the plot, ground surface cover, and other attributes relating to site biomass. These plots were established in areas exhibiting little or no disturbance and/or were identified as diverse, stable and functioning to reflect map unit component potential. In addition, there were at least three transects established for each map unit to determine map unit composition and variability. Plot data form the basis of potential natural vegetation descriptions for each map unit component whereas transects across map units form the basis for descriptions of current vegetation and ground cover conditions.

The CNF TES followed National Cooperative Soil Survey Standards similar to soil surveys conducted by the Natural Resource Conservation Service (NRCS). There was strict quality assurance including project leader field reviews, regional office reviews, and annual progressive and final field reviews to approve map unit design and mapping.

In addition to the aforementioned data acquired as part of the survey effort, TES also presents important properties pertaining to the natural, physical, and behavioral characteristics of the terrestrial ecosystems and provides the background for making interpretations. Specifically, TES provides suitability, limitation, and erosion hazard ratings for the TES map units that facilitate adjustments to land management actions. TES also provides predictions of long-term annual soil loss under various ground cover conditions including natural vegetation cover (cover conditions reflecting the potential plant community), current cover conditions, potential cover conditions assuming all ground cover is removed, and tolerance cover conditions taken to be the vegetative ground cover conditions necessary to limit soil loss to levels that sustain inherent site productivity also called soil loss tolerance. Long-term annual soil loss estimates were made for each TES map unit using the Universal Soil Loss Equation (USLE) with average values for each of the USLE variables (Wischmeir and Smith, 1978). USLE variables include a topographic factor called the slope/length (LS) factor that combines the effects of slope gradient and overland flow length, a soil erodability (K) factor that quantifies the relative susceptibility of the soil to sheet and rill erosion, a rainfall erosivity (R) factor dependent on total rainfall kinetic energy and rainfall intensity, a land cover factor dependent on the vegetative ground cover, and a conservation practices factor, which is assumed to be one where no specific soil conservation measures are employed. USLE soil loss estimates represent average long-term annual rates of soil loss for the TES map unit component as a whole and do not necessarily reflect actual soil loss conditions found throughout the map unit components primarily because of biotic, climatic, soil, and topographic variability at the project-scale.

Because of the mapping scale, the complexity of natural soil ecosystems, the intermingling of map unit components, variation can occur within a TES map unit or within the components which make up the map units. Components may also include up to two inclusions with differing properties. This spatial variability presents some challenges when presenting TES survey results and interpretations at the project level. To overcome this limitation, TES survey results and interpretations are presented for a single map unit component taken to be representative of the larger TES map unit for those map units identified as complexes or associations. Representative map unit components for a complex or association were generally selected based on their dominance within a map unit (i.e., they make up greater than 50 percent of the map unit) or based on selection of the map unit component with the most conservative value for a particular attribute being presented. For example, a map unit component with a higher soil erodability rating would typically be selected to represent soil erodability for a complex. Project specific field data, where different from TES, is considered to supercede TES data and is presented herein as noted.

2.1.2 Watershed Condition Framework

Subwatershed conditions for those subwatersheds intersecting the analysis area boundary were taken from the latest (2010) CNF watershed assessment results. The Watershed Condition Framework (WCF) protocol (USDA Forest Service, 2010a, 2010b) was used to classify watershed conditions at the 6th hydrologic unit code (HUC) level in spring, 2011 including 12 watershed indicators. Results are available at this interactive website: http://apps.fs.usda.gov/WCFmapviewer/. This section provides an overview of the USDA Forest Service watershed assessment methodology and general information regarding the classification of watersheds.

Broadly defined, a watershed or drainage basin is an area in which all portions of the landscape drain to a common outlet. The Forest Service utilizes the hydrologic unit code system developed by the USGS to classify drainage areas on lands managed by the Forest Service (Seaber, et.al., 1987). This system subdivides river basins into successively smaller hydrologic units classified into six levels which are currently identified as regions, sub-regions, basins, sub-basins, watersheds, and sub-watersheds. The hydrologic units are nested within each other, from the smallest subdivision (watersheds) to the largest division (regions). Each hydrologic unit is identified by a unique hydrologic unit code (HUC) consisting of two digits (regions) up to twelve digits (sub-watersheds or 6th code watersheds). Hydrologic units are generally named for the rivers or streams that drain them. One frequently encounters the general term “watershed” applied to any drainage basin regardless of size. In this document, an attempt is made to utilize the USGS standard terms for drainage basins of various sizes. Note that there is currently no terminology for those drainage basins nested within sub-watersheds. In this document, these smaller drainage basins are sometimes referred to as catchments or simply, drainage basins.

In order to assess the condition of sub-watersheds in a consistent fashion, the Forest Service the Watershed Condition Framework (WCF) (USDA Forest Service, 2011a) and Watershed Classification Technical Guide (USDA Forest Service, 2011b). The technical guide establishes a reconnaissance-level approach for classifying sub-watershed condition, using a comprehensive set indicators that are surrogate variables representing the underlying ecological, hydrological, and geomorphic functions and processes that affect watershed condition. The indicators are divided aquatic physical, aquatic biological, terrestrial physical, and terrestrial biological categories with of indicators and their attributes for each category (see Figure 1 and

Figure 2). The watershed condition assessment process involves classification of all sub-watersheds on National Forest lands into one of three watershed condition classes based on assigning a numerical score to each of the indicator categories: Class 1—Functioning Properly; Class 2—Functioning at Risk; Class 3—Functionally Impaired (Impaired Function). Note that not all categories are scored equally with terrestrial biological making up only 10 percent of the total watershed score and the remaining categories making up 30 percent each of the total score.

At the project level, watershed indicator scores are used to inform decisions regarding management activities so as to insure that project goals, generally expressed as desired conditions, are consistent with efforts to maintain or improve the condition of watersheds, even if the project itself won't affect indicator scores at the watershed scale. This is generally done by assessing the long-term qualitative impact (i.e., improve, maintain, or not effect) of the project on indicator categories.

Figure 1: U.S. Forest Service Watershed Condition Indicators

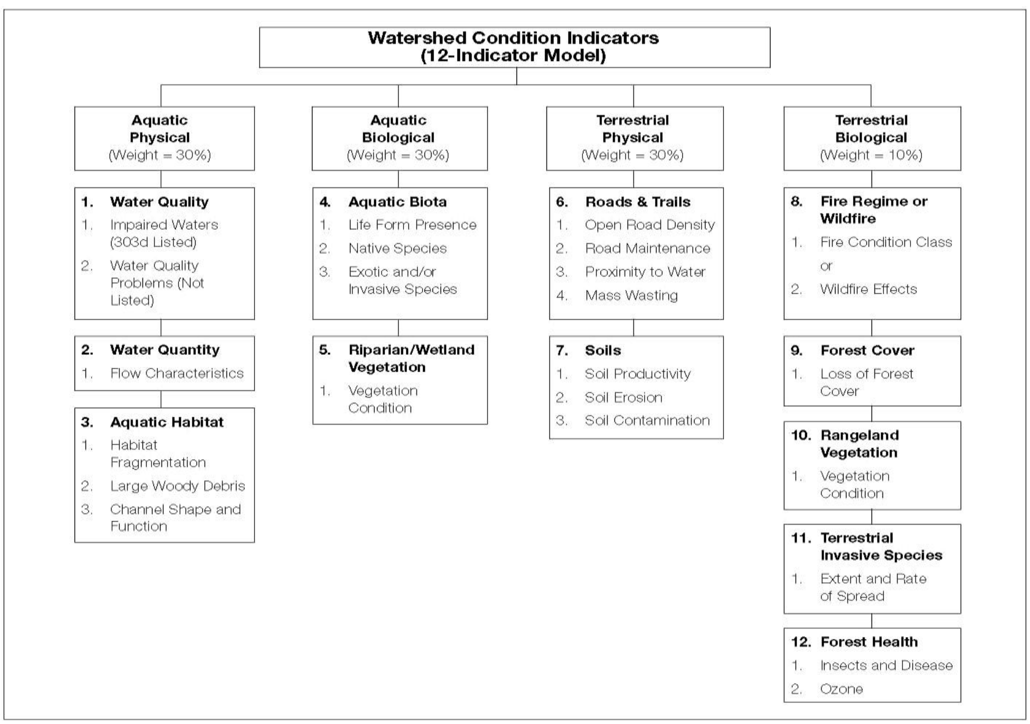


Figure 2: U.S. Forest Service Watershed Condition Indicator Descriptions

Table 1.—*Description of the 12 national core watershed condition indicators. (See the appendix for the complete rule set.)*

Aquatic Physical Indicators	
1. Water Quality	This indicator addresses the expressed alteration of physical, chemical, and biological components of water quality.
2. Water Quantity	This indicator addresses changes to the natural flow regime with respect to the magnitude, duration, or timing of the natural streamflow hydrograph.
3. Aquatic Habitat	This indicator addresses aquatic habitat condition with respect to habitat fragmentation, large woody debris, and channel shape and function.
Aquatic Biological Indicators	
4. Aquatic Biota	This indicator addresses the distribution, structure, and density of native and introduced aquatic fauna.
5. Riparian/Wetland Vegetation	This indicator addresses the function and condition of riparian vegetation along streams, water bodies, and wetlands.
Terrestrial Physical Indicators	
6. Roads and Trails	This indicator addresses changes to the hydrologic and sediment regimes because of the density, location, distribution, and maintenance of the road and trail network.
7. Soils	This indicator addresses alteration to natural soil condition, including productivity, erosion, and chemical contamination.
Terrestrial Biological Indicators	
8. Fire Regime or Wildfire	This indicator addresses the potential for altered hydrologic and sediment regimes because of departures from historical ranges of variability in vegetation, fuel composition, fire frequency, fire severity, and fire pattern.
9. Forest Cover	This indicator addresses the potential for altered hydrologic and sediment regimes because of the loss of forest cover on forest lands.
10. Rangeland Vegetation	This indicator addresses effects on soil and water because of the vegetative health of rangelands.
11. Terrestrial Invasive Species	This indicator addresses potential effects on soil, vegetation, and water resources because of terrestrial invasive species (including vertebrates, invertebrates, and plants).
12. Forest Health	This indicator addresses forest mortality effects on hydrologic and soil function because of major invasive and native forest insect and disease outbreaks and air pollution.

2.1.3 Riparian Area and Wetlands Inventorying/Assessment

The Forest Service identifies riparian areas as consisting of riparian, aquatic, and wetland ecosystems but more narrowly defines riparian ecosystems as transitional areas between the aquatic and adjacent terrestrial ecosystem identified by soil characteristics or distinctive vegetation communities that require free or unbound water (Forest Service Manual 2500;2004. Watershed and Air Management). Therefore, references to riparian areas may include both riparian and wetland ecosystems. Wetlands are defined by the Forest Service as "areas that are inundated by surface or ground water with a frequency sufficient to support and that, under normal circumstances, do or would support a prevalence of vegetation or aquatic life that requires saturated or seasonally saturated soil conditions for growth and reproduction." (Forest Service Manual 2500; 2004, Watershed and Air Management This definition comes from that put forth jointly by the U.S. Army Corps of Engineers (USACE) and U.S. Environmental Protection Agency (EPA). In its criteria for delineating wetlands, USACE (1987) requires that vegetative, soils, and hydrologic indicators all be present to designate a wetland, whereas the system used by the Forest Service and Fish and Wildlife Service (FWS) for identifying, classifying, and mapping wetlands only requires the presence of one of the three wetland indicators. Wetlands on the CNF have typically been mapped using the more restrictive criteria used by USACE. This means that some wetlands identified in the Forest Service and FWS' National Wetlands Inventory (NWI) were not included in the CNF's inventory of wetlands. Most often, those features identified in NWI as seasonally flooded wetlands created or modified by a human-made barrier or dam (e.g., stock tanks) do not appear on the CNF inventory of wetlands because they lack at least one of the three indicators of wetlands.

Riparian areas associated with stream courses were surveyed on the CNF in 1989 and 1990 using the Riparian Area Survey and Evaluation System (RASES) protocol developed by Region 3 (Southwestern Region) of the Forest Service (USDA, 1989a). Beginning in 1998, riparian areas were assessed using the proper functioning condition (PFC) riparian area assessment protocol for lotic systems developed by the U.S. Bureau of Land Management (BLM) (Pritchard, et.al., 1998). This protocol places riparian areas into one of three condition classes:

<u>Nonfunctional</u>: Riparian-wetland areas that clearly are not providing adequate vegetation, landform, or large woody debris to dissipate stream energy associated with high flows, and this are not reducing erosion, improving water quality, etc.

<u>Functional</u>: At Risk: Riparian-wetland areas that are in functional condition, but an existing soil, water, or vegetation attribute makes them susceptible to degradation.

<u>Proper Functioning Condition</u>: Riparian-wetland areas are functioning properly when adequate vegetation, landform, or large woody debris is present to:

- dissipate stream energy associated with high flows, thereby reducing erosion and improving water quality
- filter sediment, capture bedload, and aid in floodplain development
- improve flood-water retention and ground-water recharge
- develop root masses that stabilize streambanks
- develop diverse ponding and channel characteristi9cs to provide habitat for fish, waterfowl and other uses
- and support greater biodiversity

<u>Unknown</u>: Areas in which managers lack sufficient information to make any form of determination.

2.1 Existing Conditions

The resource areas that would potentially be affected by the proposed action are forest soils and watershed resources. Watershed resources include those features where water is found either permanently (perennially), intermittently, or ephemerally at the earth's surface including springs, ponds, wetlands, and stream channels as well as the watersheds that contain these features. It also includes ecosystems dependent on water resources such as riparian areas. The terms perennial, intermittent, and ephemeral are often used to convey information about the permanence of a water body. In this report, the following definitions are used (Levick, et.al., 2008):

Ephemeral: A stream or portion of a stream which flows briefly in direct response to precipitation in the immediate vicinity, and whose channel is at all times above the groundwater reservoir.

Intermittent: A stream where portions flow continuously only at certain times of the year, for example when it receives water from a spring, ground-water source or from a surface source, such as melting snow (i.e. seasonal). At low flow there may be dry segments alternating with flowing segments.

Perennial: A stream or portion of a stream that flows year-round, is considered a permanent stream, and for which baseflow is maintained by ground-water discharge to the streambed due to the ground-water elevation adjacent to the stream typically being higher than the elevation of the streambed.

2.1.1 Soil Resources

This section presents information on soil condition, erosion hazard ratings, and timber harvest limitations for TES map units found within the analysis area.

2.1.1.1 SOIL CONDITION

A soil condition category is assigned to each TES map component either through USLE predictions regarding long-term annual soil loss or using the soil quality (condition) assessment and rating protocol developed for Region 3 of the Forest Service (file 2550; January 16, 2013)). Soil condition ratings are based on interpretations of the three primary soil functions: soil hydrologic function, soil stability and nutrient cycling. In general, hydrologic function of the soil is assessed based on indications of reduced infiltration through compaction and modification of surface soil structure. Field estimates of infiltration may be conducted using a single ring infiltrometer or other infiltration measuring device to estimate infiltration. Soil stability is generally assessed through visual inspection of the soil surface for evidence of erosion including rilling, pedestaling (i.e., plants or rock fragments elevated above surrounding soil), and soil displacement. Nutrient cycling is generally assessed by visual observation of surface litter (distribution and depth), presence of coarse woody material, and root distribution within the surface soil horizons. Though not always possible, application of soil condition rating protocol at the project level is preferable to TES soil condition ratings based on USLE since it involves filed-verifiable indicators of soil condition.

Soil condition classes used are Satisfactory, Impaired, and Unsatisfactory. The following are definitions describe each class.

Satisfactory: Indicators signify that soil function is being sustained and soil is functioning properly and normally. The ability of the soil to maintain resource values and sustain outputs is high.

Impaired: Indicators signify a reduction in soil function. The ability of the soil to function properly and normally has been reduced and/or there exists an increased vulnerability to degradation. An impaired category indicates there is a need to investigate the ecosystem to determine the cause and degree of decline in soil functions. Changes in land management practices or other preventative measures may be appropriate.

Unsatisfactory: Indicators signify that a loss of soil function has occurred. Degradation of vital soil functions result in the inability of the soil to maintain resource values, sustain outputs or recover from impacts. Unsatisfactory soils are candidates for improved management practices or restoration designed to recover soil functions.

Although not a soil condition category under the soil condition assessment and rating protocol, TES included a soil rating category termed “Inherently Unstable or Unsuited”. This category applies to soils with Universal Soil Loss Equation (USLE)-predicted long-term annual soil loss rates under climax cover conditions exceeding tolerable limits, a condition that frequently occurs on slopes exceeding 40%.

TES map units and associated soils conditions within the Dry Lake Hills (DLH) and Mormon Mountain (MM) portions of the analysis area are identified in Table 1 and Table 2. All TES map units within the entire analysis area are currently in satisfactory condition with the exception of TES map unit 55, which is rated as impaired. The satisfactory condition of soils in the analysis area is generally attributed to high amounts of vegetative ground cover, including vegetation basal area and litter, which serves to protect the soil from raindrop impact and dissipate the energy of overland flow. Despite this overall rating, nutrient cycling within ponderosa pine and mixed conifer vegetation types has been observed to be less than satisfactory as a result of low understory species diversity. This low diversity of understory species is typically the result of a dense overstory canopy cover that limits growth of herbaceous plants. In the case of TES map unit 55, representing montane meadows, soils have been found to have ground cover substantially less than TES-predicts for site potential for possible reasons ranging from conifer encroachment to grazing by domestic and wild ungulates.

Table 1: Soil Conditions Data within the Dry Lake Hills Portion of the Analysis Area

TES Map Unit	Sum of Area (acres)
Not applicable	**5**
City	5
Satisfactory	**7564**
551	1970
584	328
586	94
595	13
596	1370
611	85
613	2008
640	65
653	234
654	1398
Grand Total	**7569**

Table 2: Soil Conditions Data within the Mormon Mountain Portion of the Analysis Area

TES Map Unit	Sum of Area (acres)
Impaired	**63**
55	63
Satisfactory	**4183**
557	178

565	125
575	8
582	215
584	889
585	638
586	379
613	393
653	491
654	867
Grand Total	**4246**

2.1.1.2 SOIL INTERPRETATIONS

Erosion Hazard

TES defines erosion hazard as the probability of soil loss resulting from the complete removal of vegetation and litter. It is determined though a comparison of the potential soil loss rate for a map unit component as calculated using USLE to the estimated tolerance soil loss rate for a map unit component. A slight rating indicates that all vegetative ground cover could be removed from the site and the resulting soil loss would not exceed "tolerance" soil loss rates. A moderate rating indicates that predicted rates of soil loss would result in a reduction of site productivity *if left unchecked*. Conditions in moderate erosion hazard sites are such that reasonable and economically feasible mitigation measures can be applied to reduce or eliminate soil loss. A severe rating indicates that predicted rates of soil loss have a high probability of reducing site productivity before mitigating measures can be applied. Erosion hazard ratings for soils within the DLH and MM analysis areas are shown in Figure 3 and Figure 4.

Since erosion hazard rating is determined through the potential soil loss rate calculated assuming no vegetative cover (i.e., the land cover factor in USLE is assigned a value of one) and rainfall erosivity factors are not expected to vary over a project area, the factors that may be influencing erosion hazard rating at the project scale include the soil erodability (K) factor and LS factor. K factors are influenced by the complex interactions of the various soil properties, including physical, chemical, and mineralogical. Nationwide, soil erodability factors have been reported to range from near zero to about 0.6 with factors less than 0.2 associated with soils in which water readily infiltrates (high infiltrability), factors between 0.2 and 0.3 associated with soils having an intermediate infiltrability, and soils with factors greater than 0.3 having a low infiltrability (Brady 1995). Infiltrability of a soil, defined as the rate at which water enters the soils, effects the amount of runoff with higher runoff for soils with low infiltrability. Other soil properties affecting the K factor include soil texture, organic matter content, soil structure, and cohesion, however, these soil properties should not be considered independent of one another since, for example, soil texture, soil structure, and organic matter content influence infiltrability and organic matter content influences soil structure. In general, soils having a large amount of silt-sized particles are most susceptible to erosion whereas soils with high clay or sand-sized particles are less prone to erosion. Those soils with high clay content are more cohesive owing to greater binding forces between particles but have low infiltration rates whereas soils with high sand content are less cohesive but generally have higher infiltration rates.

The majority of soils in map units associated with the DLH analysis area have low soil erodability factors, however, many of these same soils are assigned moderate to severe erosion hazard ratings. This can generally be explained by the steep slopes associated with map units in the DLH area. Slope has a strong influence on erosion as reflected in USLE since runoff velocity is a function of slope gradient. The majority of soils associated with TES map units in the MM analysis area have moderate soil erodability factors. Map units with severe erosion hazard ratings are often found on steep slopes.

Figure 3: Erosion Hazard Ratings within the DLH Analysis Area

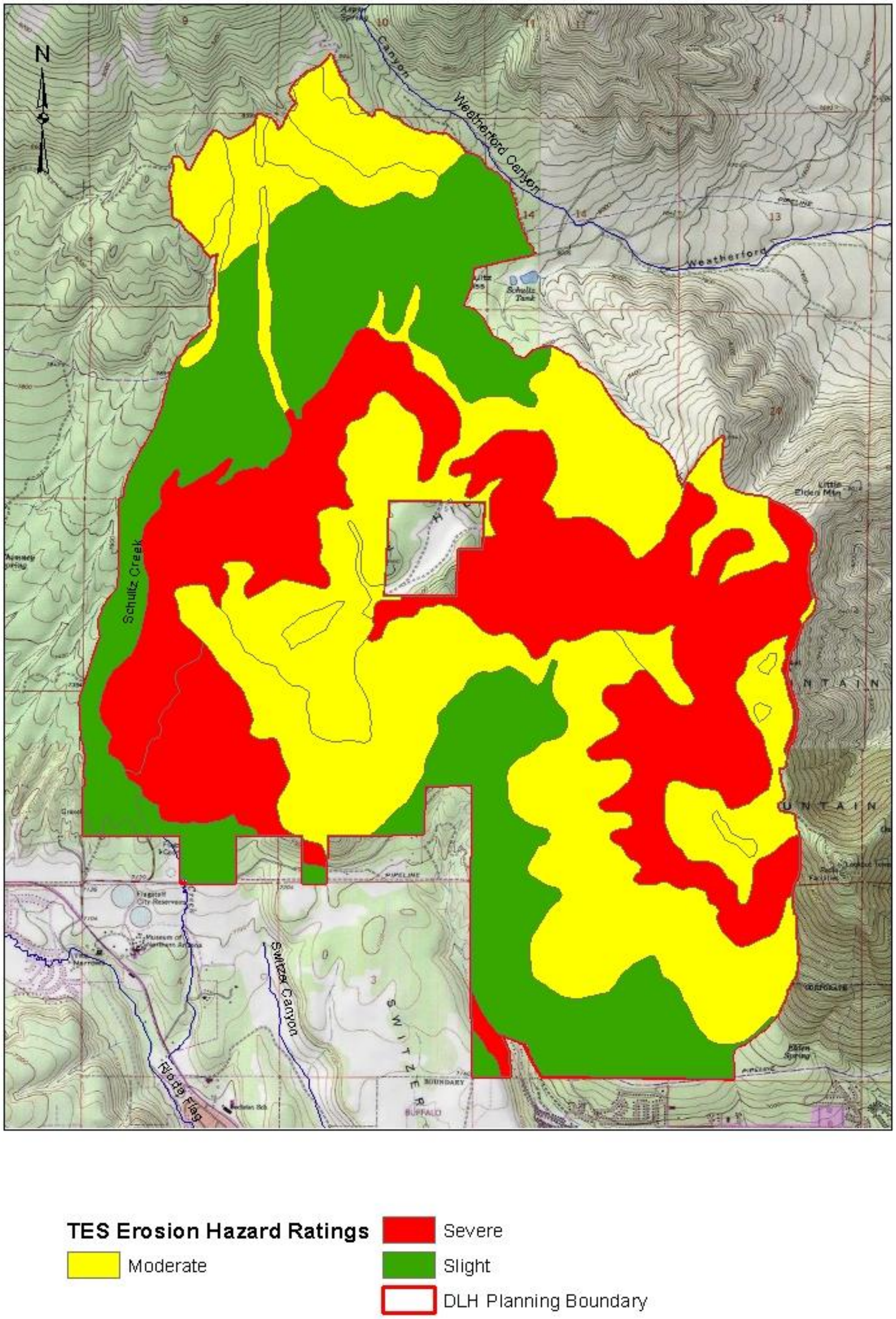
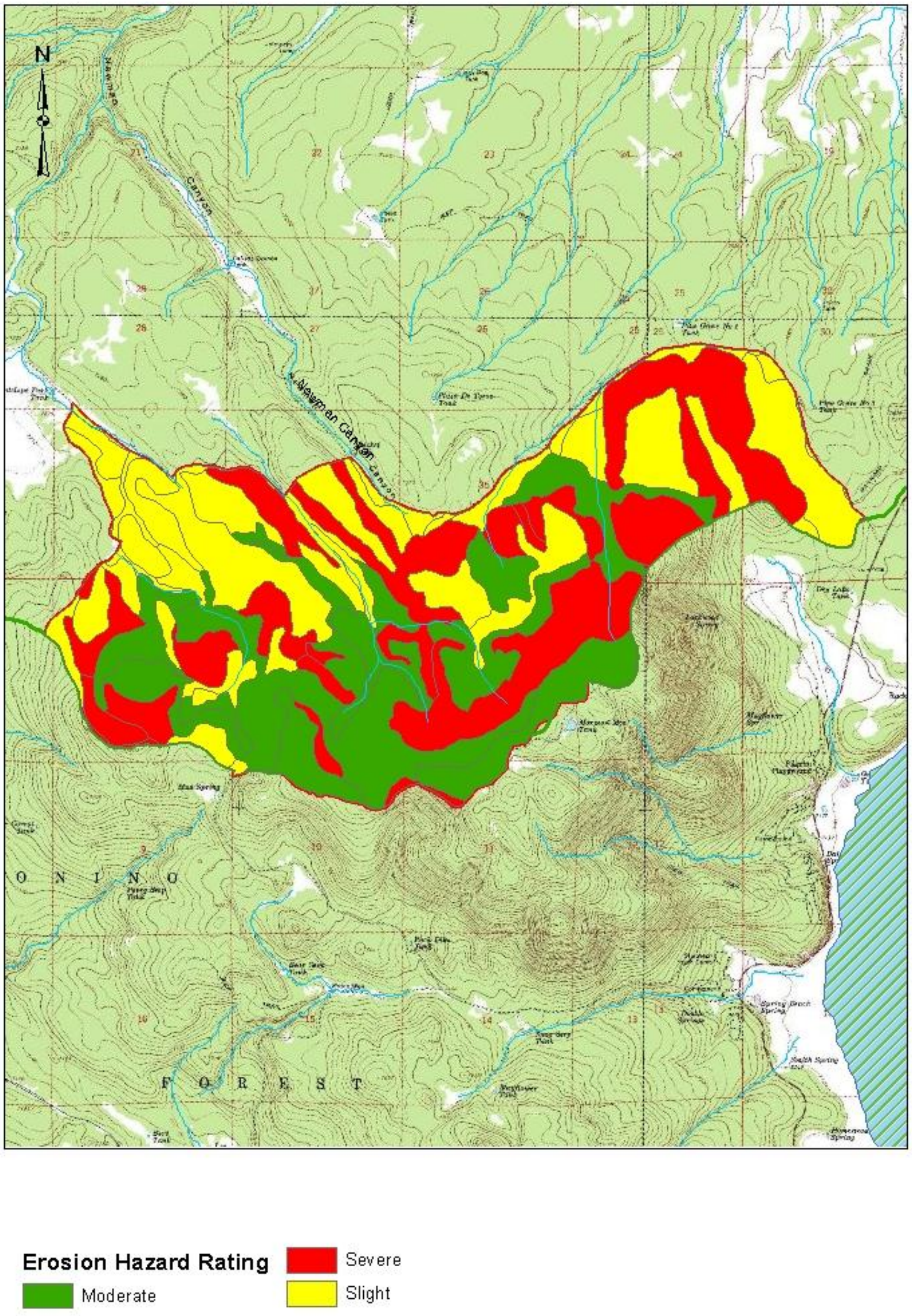


Figure 4: Erosion Hazard Ratings within the Mormon Mountain Analysis Area



Timber Harvest Limitation Ratings

TES identifies timber harvest limitations as the limits to be considered when evaluating the suitability of timber harvesting by equipment use with regard to maintenance of soil productivity (Miller, et.al., 1995). Limits relate to year-round or seasonal use of equipment as the result of climate, soil characteristics, and landform. A slight rating indicates that mechanized harvesting can be performed year round with a low risk of soil productivity impairment. A moderate or severe rating directs the land manager to areas that require some measure of mitigation in order to avoid impairment of soil productivity. Timing of thinning operations can often be used to mitigate soil moisture problems. For example, thinning can be performed during frozen ground or dry conditions to minimize risk of soil compaction and rutting. Additionally, slope limitations can be established for different thinning treatments. Timber harvest limitation ratings for the analysis area are shown in Figure 5 and Figure 6.

Figure 5: Timber Harvest Limitation Ratings within the DLH Analysis Area

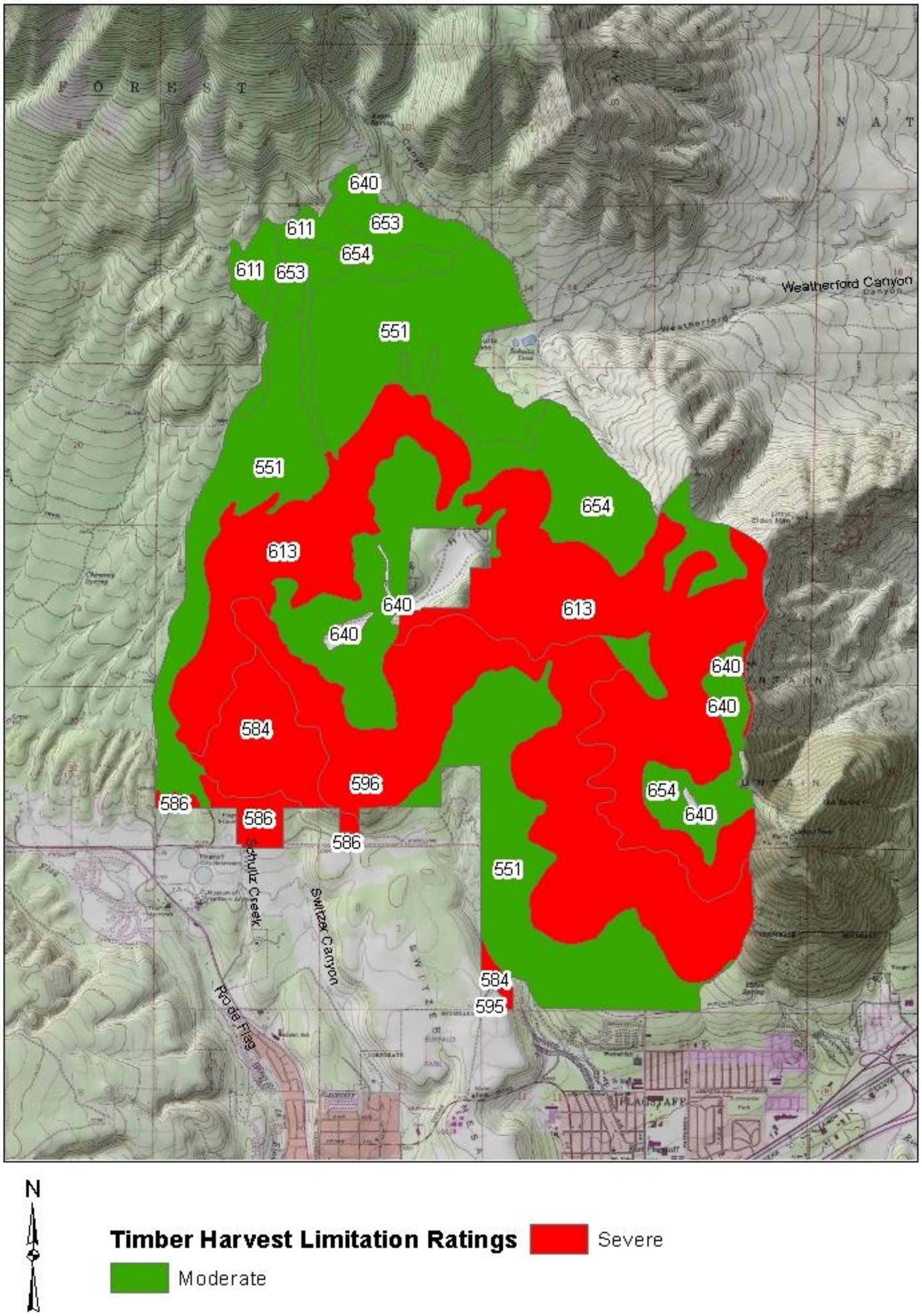
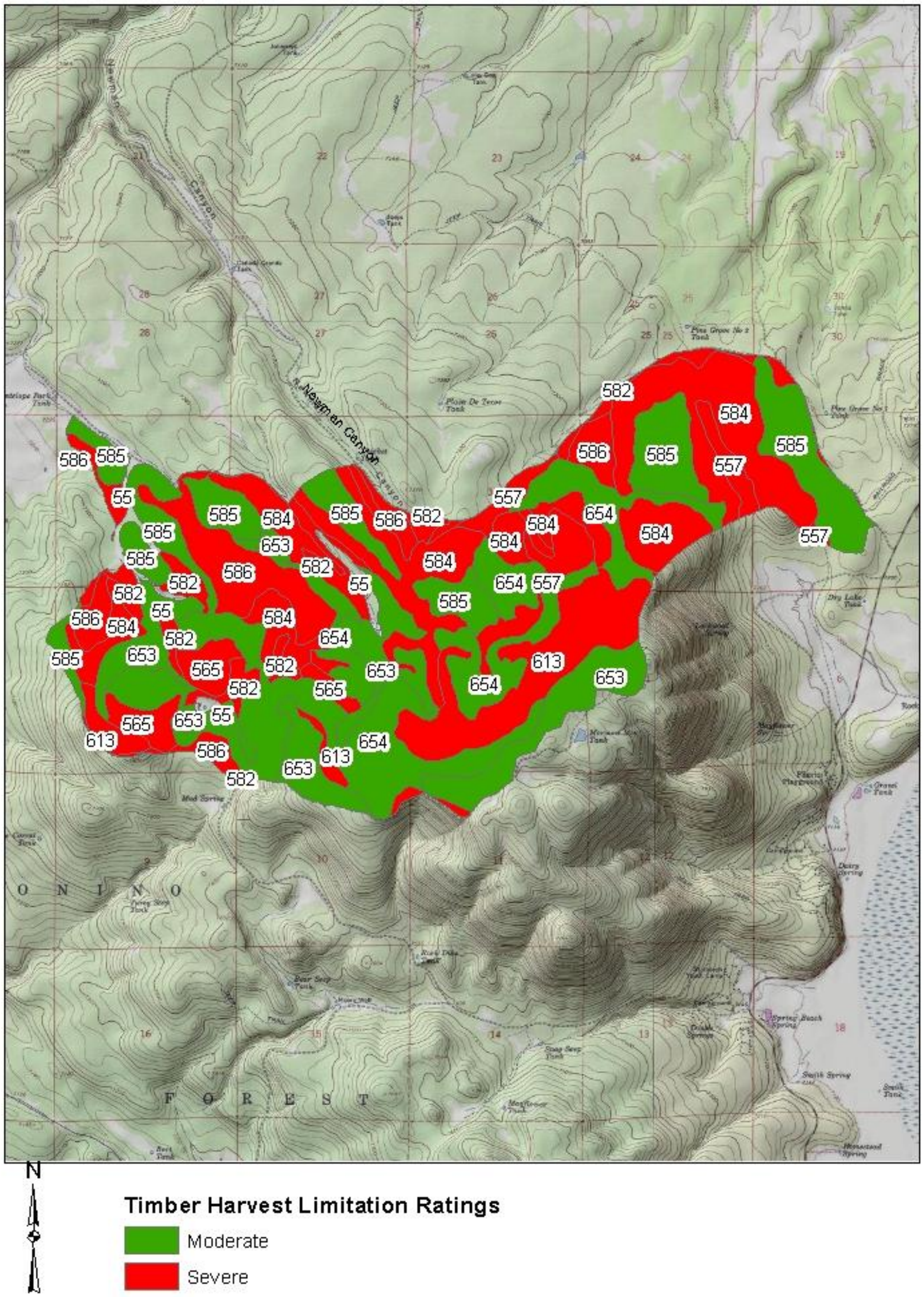


Figure 6: Timber Harvest Limitation Ratings within the Mormon Mountain Analysis Area



2.2.2 Water Resources

2.2.2.1 WATERSHEDS

The spatial relationship of the DLH analysis area to sub-watersheds is shown in Figure 7. The DLH analysis area occurs mostly within the Upper and Lower Rio De Flag subwatersheds with the analysis area's northeastern boundary roughly coincident with the western boundary of the Doney Park sub-watershed. All three of these sub-watersheds are in the larger Rio De Flag watershed, which drains to the Little Colorado River to the east. The analysis area is drained by two drainage areas tributary to the Rio De Flag; Schultz Creek and Spruce Avenue Wash as shown in Figure 8.

The MM analysis area is almost entirely within the Walnut Creek-Upper Lake Mary (ULM) sub-watershed as shown in Figure 9. The flow of surface water to Upper Lake Mary is derived from the Walnut Creek – ULM sub-watershed. This sub-watershed is part of the Walnut Creek watershed which drains to the San Francisco wash, located east of Flagstaff, and eventually, to the Little Colorado River. Three drainage areas with outlets at Upper Lake Mary, informally referred to Newman basin, Middle basin, and East basin, drain the MM analysis area as shown in Figure 10.

Table 3 displays the watershed condition indicator scores for those subwatersheds which intersect the analysis area. The Walnut Creek-ULM subwatershed was given an overall rating of "impaired function" during watershed condition assessments conducted in 2010. Six of the twelve indicators of watershed condition were rated as "poor" or "fair;" however, implementation of the Travel Management Rule (2011) resulted in a reduction of the open road system density in this watershed to just under one mile open road/square mile of watershed. This places the roads and trails indicator for this watershed in the "good" category. The Upper Rio De Flag subwatershed was given an overall rating of "functioning at risk" whereas the "Lower Rio De Flag subwatershed was rated as "functioning properly." One of the indicators of watershed condition particularly relevant to the proposed action is indicator 8, fire regime or wildfire condition. This indicator addresses the potential for altered hydrologic function and sediment transport because of departures from historical ranges of variability in vegetation, fuel composition, fire frequency, fire severity, and fire pattern (USDA Forest Service, 2011b) . Although this indicator was rated as "good" for all the subwatersheds intersected by the analysis area, a more detailed analysis of an attribute of this indicator, fire regime condition class (FRCC), is provided in the Fire/Fuels Specialist Report specifically for the analysis area. FRCC provides an assessment of the extent to which current vegetation, in terms of composition and structure, departs from simulated historic vegetation reference conditions due to an absence of fire and an increase in fire return intervals for a particular natural fire regime (USDA Forest Service, 2011b). It is strictly a measure of ecological trends. There are five natural fire regimes classified based on the average number of years between fires combined with the severity (amount of replacement) of the fire on the dominant overstory vegetation as defined in Table 4 (Hann, et.al., 2004).

Table 3: Watershed Qualititative Indicator Ratings for Sub-watersheds that Drain the Analysis Area

Sub-Watershed	Indicator 1 - Water Quality	Indicator 2 - Water Quantity	Indicator 3 - Aquatic Habitat	Indicator 4 - Aquatic Biota	Indicator 5 - Riparian/ Wetland Vegetation	Indicator 6 - Roads and Trails	Indicator 7 - Soils	Indicator 8 - Fire Regime or Wildfire	Indicator 9 - Forest Cover	Indicator 10 - Rangeland Vegetation	Indicator 11 - Terrestrial Invasive Species	Indicator 12 - Forest Health
Upper Rio de Flag	fair	fair	fair	fair	fair	fair	good	good	good	good	good	fair
Lower Rio de Flag	good	good	good	good	fair	fair	good	good	good	good	good	good
Walnut Creek-Upper Lake Mary	poor	fair	poor	poor	good	good	good	good	good	good	good	poor

Table 4: Natural Fire Regime Groups (From: Interagency Fire Regime Condition Class Guidebook, September 2010).

Group	Frequency	Severity	Severity description
I	0 – 35 years	Low / mixed	Generally low-severity fires replacing less than 25% of the dominant overstory vegetation; can include mixed-severity fires that replace up to 75% of the overstory
II	0 – 35 years	Replacement	High-severity fires replacing greater than 75% of the dominant overstory vegetation
III	35 – 200 years	Mixed / low	Generally mixed-severity; can also include low-severity fires
IV	35 – 200 years	Replacement	High-severity fires
V	200+ years	Replacement / any severity	Generally replacement-severity; can include any severity type in this frequency range

There are three fire regime condition classes. Condition class 1 describes fire regimes and vegetation-fuel conditions considered to be within reference condition range of variability whereas condition classes 2 and 3 represent moderate and high departures from reference condition range of variability, respectively. A more detailed description of fire regime condition classes and potential risks is provided in Table 5.

Table 5: Fire Regime Condition Classes and Potential Risks

Fire Regime Condition Class	Description	Potential Risks
Condition Class 1	Within the natural (historical) range of variability of vegetation characteristics; fuel composition; fire frequency, severity and pattern; and other associated disturbances	Fire behavior, effects, and other associated disturbances are similar to those that occurred prior to fire exclusion (suppression) and other types of management that do not mimic the natural fire regime and associated vegetation and fuel characteristics. Composition and structure of vegetation and fuels are similar to the natural (historical) regime. Risk of loss of key ecosystem components (e.g. native species, large trees, and soil) are low
Condition Class 2	Moderate departure from the natural (historical) regime of vegetation characteristics; fuel composition; fire frequency, severity and pattern; and other associated disturbances	Fire behavior, effects, and other associated disturbances are moderately departed (more or less severe). Composition and structure of vegetation and fuel are moderately altered. Uncharacteristic conditions range from low to moderate; Risk of loss of key ecosystem components are moderate
Condition Class 3	High departure from the natural (historical) regime of vegetation characteristics; fuel composition; fire frequency, severity and pattern; and other associated disturbances	Fire behavior, effects, and other associated disturbances are highly departed (more or less severe). Composition and structure of vegetation and fuel are highly altered. Uncharacteristic conditions range from moderate to high. Risk of loss of key ecosystem components are high

As discussed in the Fire/Fuels Specialist Report, approximately 88 percent (4,783 acres) of the DLH portion of the analysis area is in fire regime I, condition class 3 with most of the remaining area in fire regime III, condition class 3 (1,487 acres). Within the MM portion of the analysis area, approximately 89 percent (2,646 acres) is within fire regime I, condition class 3. This high departure from natural (reference) conditions highlights the vulnerability of the catchments draining the analysis area to a fire that would likely greatly alter the catchment hydrologic response, rate of erosion, and sediment transport (Neary, et.al., 2005).

Figure 7: Sub-watersheds Intersectiing the DLH Analysis Area

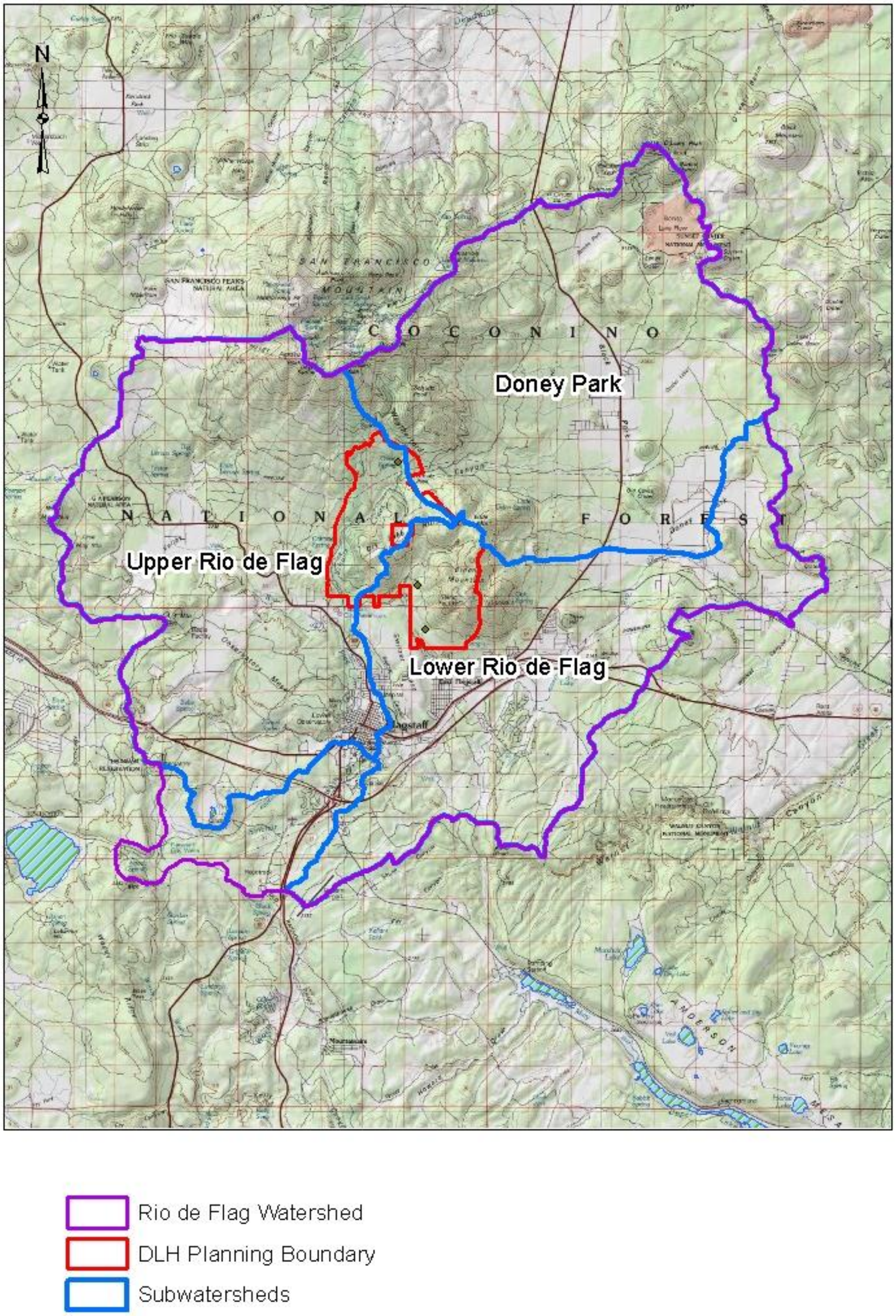


Figure 8: Streamcourses and Drainage Areas within the DLH Portion of the Analysis Area

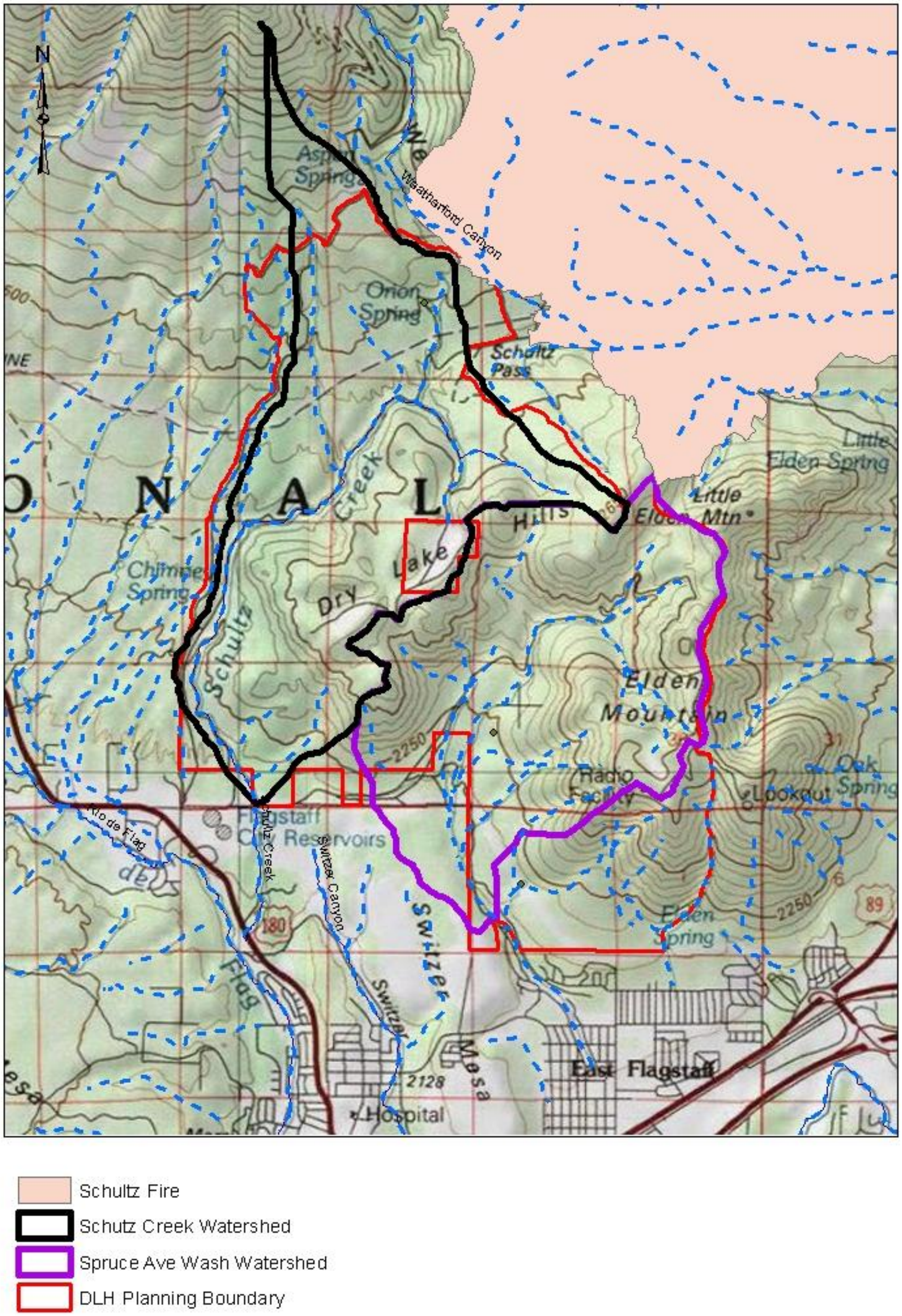


Figure 9: Sub-watersheds Intersecting the Mormon Mountain Analysis Area

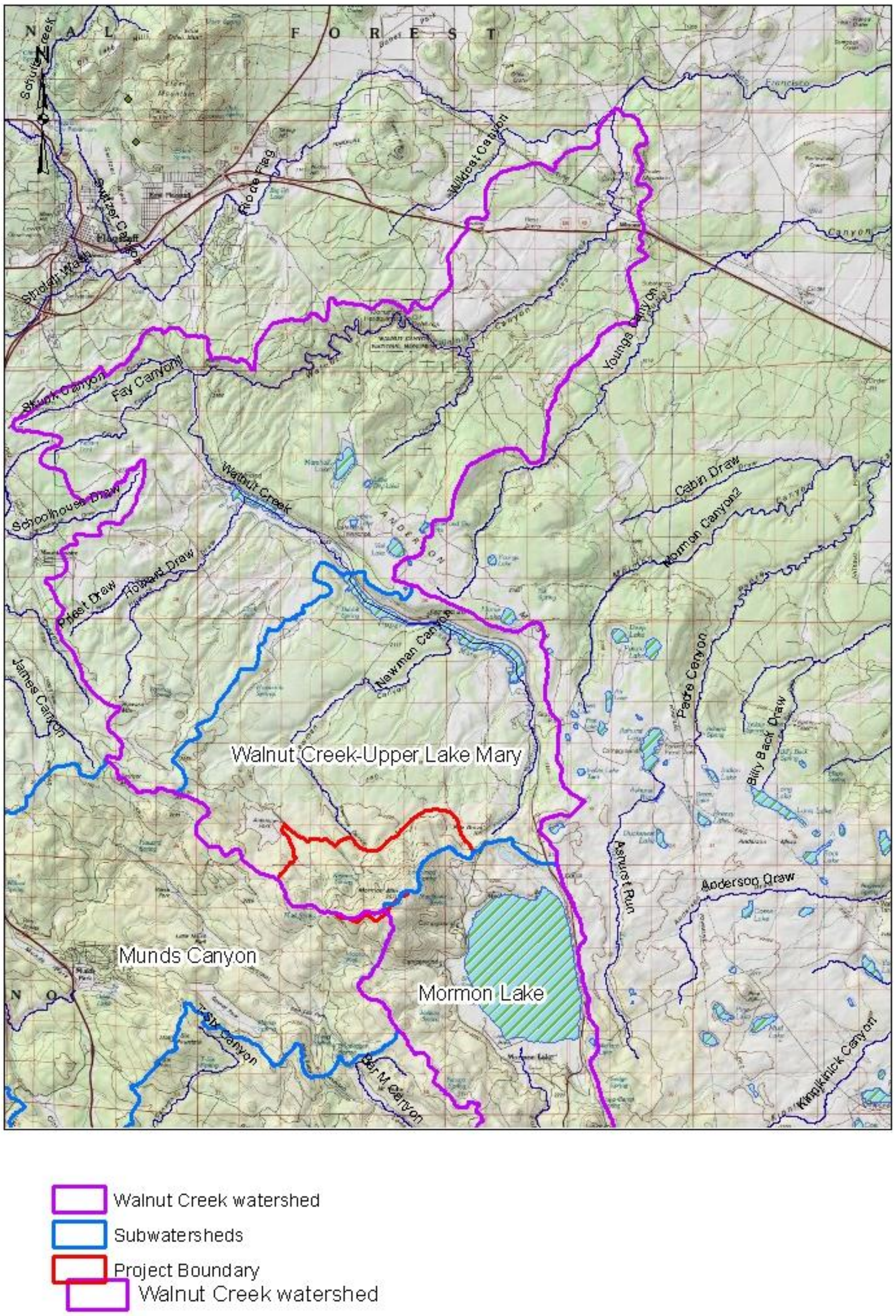
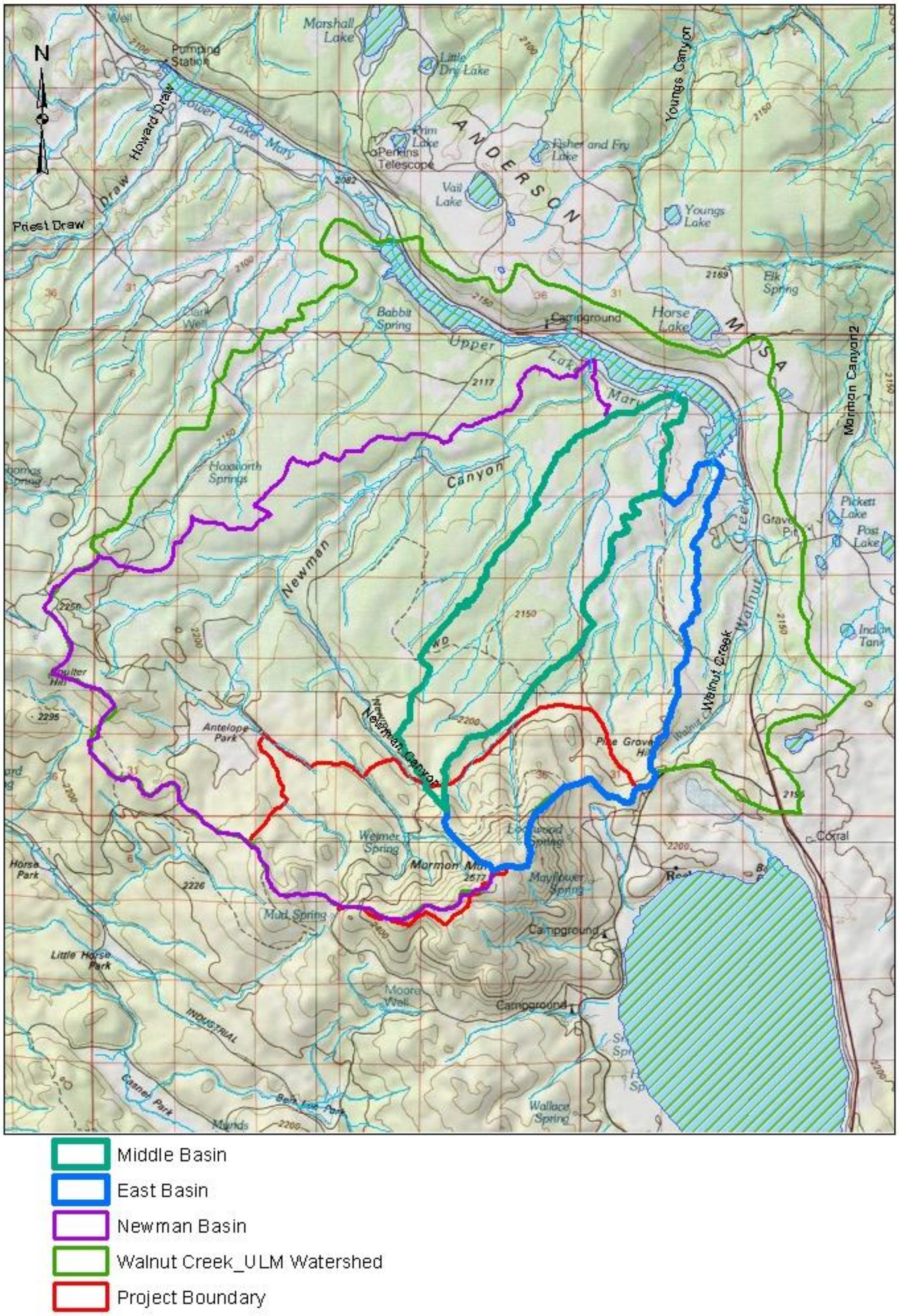


Figure 10: Streamcourses and Drainage Areas within the Mormon Mountain Analysis Area



2.2.2.2 STREAMCOURSES

Those streamcourses within the analysis area that are identified as such on USGS 7.5 minute quadrangle maps are shown in Figure 8 and Figure 10 for the DLH and MM areas, respectively. There are two main drainages in the DLH-portion of the project area; Schultz Creek and Spruce Avenue Wash. These drainages are both tributary to the Rio De Flag. Schultz Creek joins the Rio De Flag just south of the Museum of Northern Arizona on State Highway 180. Spruce Avenue Wash joins Switzer Canyon Wash prior to entering the Rio De Flag just southeast of the intersection of East Butler Avenue and South 4th Street in Flagstaff, Arizona. Flow data for these drainages is limited to measurements of peak discharge as estimated using crest-stage gages installed and monitored as part of a USGS study of the flood hydrology in and around the City of Flagstaff (Hill, et.al., 1988). In six of eleven years of gage data, no discharge was recorded for the Schultz Creek drainage. In the eleven year period of record spanning from 1970 to 1980, the highest peak discharge of 48 cubic feet/second (CFS) was recorded in April 1973. The no or low annual peak discharge estimates for Schultz Creek are likely attributable to the mostly undeveloped nature of the Schultz Creek drainage basin combined with its high amount of vegetative ground cover, high infiltration rates of the associated forest soils, underlying geology, and its position relative to subsurface water-bearing zones. Based on the USGS flow estimates and a lack of facultative wetland species throughout much of its length, Schultz Creek is an ephemeral stream. There may, however, be portions of the roughly six mile long drainage with more persistent surface water as has been observed in the vicinity of the Schultz Creek and Sunset trail intersection where willows (Salix sp.) are present and surface water has been observed persisting into June, which is usually the driest month of the year.

As part of the same USGS study referenced above, annual peak discharge estimates for Spruce Avenue Wash (referred to as the Switzer Canyon Tributary by the USGS) were made from crest-stage gage measurements spanning a 12 year period of record beginning in 1968 and ending in 1980. Annual peak discharge estimates for this drainage ranged from a low of 15 CFS in December of 1971 to a high of 262 CFS in August of 1968. The USGS study concluded that most of the runoff in this drainage originated from the urbanized portion of the drainage basin. Although the amount of runoff generated in the undeveloped portion of the drainage basin occurring on Forest Service-managed lands was not determined, observations made where the Spruce Avenue Wash crosses Cedar Street indicated that runoff did not reach the urban part of the watershed and the highest peak discharge was estimated to be five CFS, presumably based on an observation of flow debris. The limited discharge from the un-urbanized portion of the Spruce Avenue Watershed is probably attributable to the same factors limiting flow in Schultz Creek and this drainage is also classified as ephemeral.

There are two main streamcourses with headwaters in the MM-portion of the project area that enter Lake Mary as shown in Figure 10: Newman Canyon and an unnamed streamcourse. Roughly 44 percent of the project area (1300 acres) drains through Newman Canyon. Except for roughly 22 acres (less than one percent) of the project area that drains through Railroad Wash entering roughly the upper portion of Upper Lake Mary, surface flow from the remainder of the project area is directed through an unnamed drainage entering the upper end of Upper Lake Mary. No flow data exists for these drainages, but the size and elevation of the contributing watersheds suggest that these drainages may be intermittent flowing for extended periods during the spring from snow melt.

2.2.2.3 WATER QUALITY

The Arizona Department of Environmental Quality (ADEQ) is responsible for establishing state water quality standards and monitoring the quality of the state's surface water. Under Section 305 of the Clean Water Act, ADEQ is required to conduct a comprehensive assessment of water quality data associated with Arizona's surface waters to determine whether state water quality standards are being met and designated uses of these waters are being supported. This analysis, conducted every two years, is published as a report referred to as the Water Quality Assessment Report or "305(b) Report." Based on the results of this assessment, surface waters are classified into one of five categories (as shown below in Table 6) and a list of impaired waters is generated. This list is often referred to as the "303(d) List" and those waters on the list are referred to as "listed waters." Waters on this list require that a Total Maximum Daily Load (TMDL) study be completed to determine the total load of a pollutant that can be discharged to the water body on a daily basis while still meeting the applicable water quality standard. ADEQ's surface water monitoring program is typically focused on perennial waters due to the difficulties of reliably predicting the presence of water to sample in intermittent and ephemeral waters.

Table 6: Five categories determined in the Water Quality Assessment Report by ADEQ

Category Number	Category	Description
1	Attaining All Uses	All uses were assessed as "attaining uses", all core parameters monitored
2	Attaining Some Uses	At least one designed use was assessed as "attaining," and no designated uses were not attaining or impaired
3	Inconclusive or Not Assessed	Insufficient samples or core parameters to assess *any* designated uses
4	Not Attaining	One or more designated use is not attaining, but a TMDL is *not* needed
5	Impaired	One or more designated use is not attaining, and a TMDL is needed

There is limited water quality data available for streamcourses within or immediately downstream of the analysis area. ADEQ's most recent assessment of surface water quality included two streamcourses with their headwaters at roughly the northern boundary of the

MM-portion of the analysis area: Newman Canyon and Railroad Wash (ADEQ, 2012). Both streamcourses were rated as “inconclusive” though no exceedances of state water quality standards were reported during the respective sampling periods. Both streamcourses were sampled near their inlets to Upper Lake Mary. ADEQ also assessed and rated as “inconclusive” a 3.7 mile reach of the Rio De Flag extending from the discharge outfall for the City of Flagstaff’s Wildcat Hill wastewater treatment facility to San Francisco Wash. No exceedances of state water quality standards were reported during the sampling period. This reach is downstream of locations where Schultz Creek and Spruce Avenue Wash/Switzer Canyon enter the Rio De Flag.

In 2002, five lakes in what is referred to as the “Lake Mary Region” (LMR) including Upper Lake Mary, were listed as impaired for mercury in fish tissue. A TMDL study of the LMR lakes was completed in 2010 (ADEQ, 2012). Potential sources of mercury identified in the report included direct atmospheric deposition to the lakes, and input of sediment containing mercury from atmospheric deposition or existing naturally in soil parent material. In Upper Lake Mary, 81 percent of the average annual loading of mercury for a 10 year period was estimated to be from sediment input to the lake, whereas 19 percent was attributed to direct atmospheric deposition. It was further determined that most of the annual sediment loading was from transport by snowmelt though average mercury concentrations in runoff during August and November were more than twice average mercury concentrations in runoff during January through April.

2.2.2.4 RIPARIAN AREAS, WETLANDS, and SPRINGS

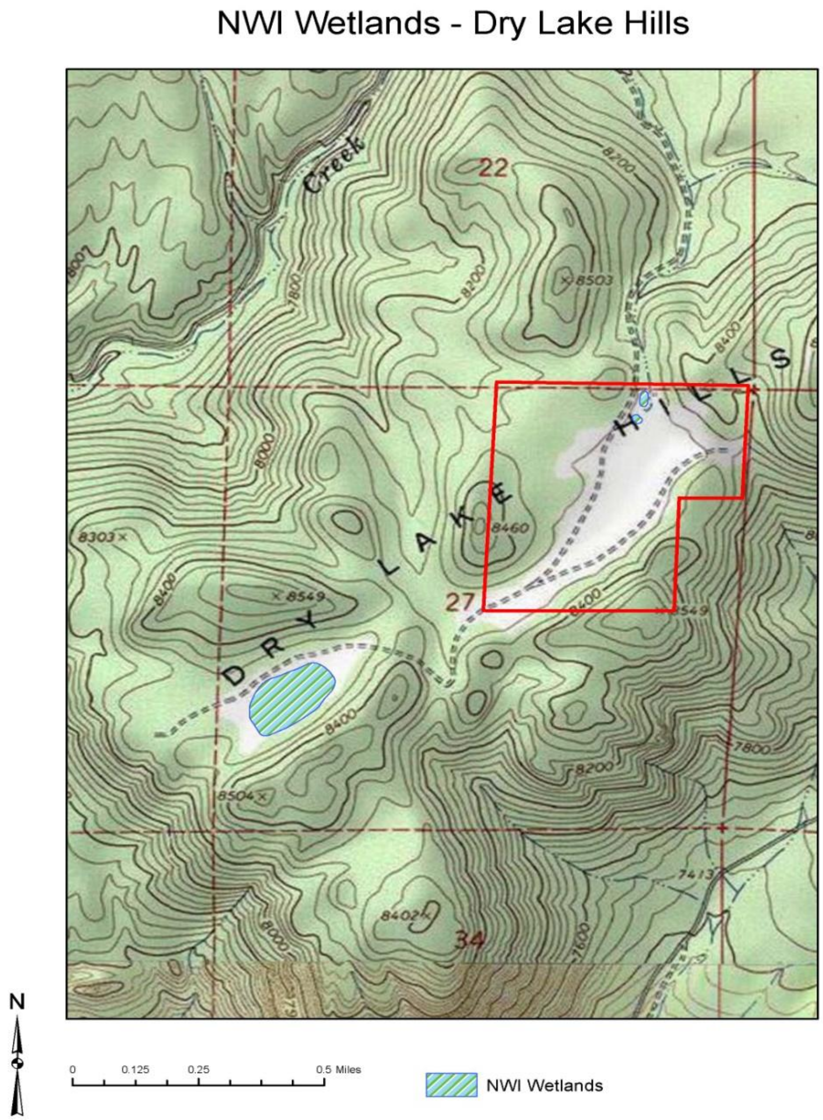
The analysis area contains one feature mapped as a wetland by the National Wetlands Inventory (NWI), which is located in the DLH-portion of the project area and commonly known as “Dry Lake” (see Figure 11). NWI identifies this wetland as having a “temporary flooded” water regime defined as having surface water present for brief periods during the growing season but having a water table well below the soil surface for most of the growing season. This water regime may support plants characteristic of both upland and wetland environments. A private inholding within the DLH-portion of the analysis area has two NWI-mapped wetlands that have been modified by a human-made barrier, which may be impounding surface water for much longer periods than would naturally occur.

The drainages within both portions of the analysis area are ephemeral or intermittent generally lacking surface water except for brief periods during the summer monsoon or for longer periods during the spring from snow melt. The absence of surface water combined with the depth to groundwater found throughout most of the analysis area precludes the presence of riparian areas. There are, however, some sections of Schultz Creek, particularly in the upper reaches, where surface water has been observed to persist into seasonally dry periods, and where willows are locally abundant. Such a reach can be found near the vicinity of the Schultz Creek and Sunset trail intersection. Persistent surface water and willows may be locally present where subsurface geologic conditions favor elevated levels of soil moisture. For the most part, Schultz Creek is surrounded by upland species and the stream channel is characterized by a boulder/cobble matrix that effectively dissipates stream energy during infrequent flow events.

There are three mapped springs (i.e., those that have been identified on USGS topographic maps) in the analysis area including Orion Spring and an unnamed spring in the DLH-portion of the project area, and Weimer Spring in in the Mormon Mountain-portion of the project area. These springs are not supported by discharge from the regional aquifer, which is located several thousand feet below the earth's surface in the analysis area, but are supported by perched water bearing zones that may be seasonally dry or drier for longer periods in response to extended drought periods. There is no flow or water quality data for any of the springs.

No surface water was present at Orion Spring during a field visit in June of 2013. This spring has been used in the past for stock watering and a statement of claim of right to use public waters of the state was filed for this water source by a private entity in May 1978 for stock watering and wildlife use. There is evidence that the spring or its runout channel has been diverted by pipe to various storage systems in the past, though ongoing maintenance of diversion and water storage systems is not apparent. A spring box or other collection device at the spring source could not be located. The unnamed spring in the DLH-portion of the project area is located at the base of the southwest side of Mount Elden. The spring emergence point could not be located during a field visit conducted in the fall of 2012 and no surface water was present in the vicinity of the map location of the spring, suggesting that there is likely limited discharge of perched groundwater supporting this feature. Weimer spring is a developed water source with a State of Arizona Certificate of Water Right issued to the Coconino National Forest dated October 3, 1940 for the purpose of domestic and stockwatering use. According to the water right application, the spring emergence point was developed by installation of a spring box constructed of 24-inch diameter culvert installed to a depth of 5.5 feet with spring discharge diverted from the culvert by pipe to a series of wood troughs. The spring box is still in place, though the diversion and storage systems have fallen into disrepair.

Figure 11: Mapped Wetland within Dry Lake Hills-Portion of Analysis Area



Desired Condition

The following desired conditions for soils and water resources are based on applicable state and Federal laws, Forest Service direction, and the professional judgment of the specialist.

- Critical soil functions and processes including the infiltration and storage of water, the cycling and storage of nutrients, and the maintenance of diverse populations of native soil microflora are enhanced or preserved. Management activities do not produce substantial and permanent impairment of land productivity.

- Water quality meets state standards for designated uses. Sediment inputs to stream courses do not contribute to impairment of stream courses or other water bodies.

- Riparian areas and stream channels are functioning properly or show a trend towards an improving condition where sufficient bed materials, native vegetation, landforms, soil condition, and woody debris are present to:
    - Dissipate water energy, thereby reducing erosion and improving water quality;
    - Filter sediment, capture bedload, and contribute to floodplain development;
    - Improve flood-water retention and ground water recharge;
    - Develop root biomass that stabilizes channel banks against scour, slumping, and erosion;
    - Develop diverse ponding characteristics to provide habitat and water depth, duration, and temperature necessary for aquatic/amphibian habitat, waterfowl breeding, and other uses.

- Susceptibility of soils and water resources to the potential negative consequences from an uncharacteristic wildfire are minimized through restoration of vegetation conditions to approximate historic conditions.

Environmental Consequences

This section describes the direct, indirect, and cumulative effects of implementing each alternative on affected soils and water resources. Affected soils are those forest soils occurring within the analysis area that may be impacted by the no action and proposed action alternatives. Affected water resources include water quality, water yield, springs, and wetlands/riparian areas.

Direct effects of the alternatives are caused by the action and occur on site and affect only the area where they occur. Indirect effects are caused by the action and are later in time or farther removed in distance, but are still reasonably foreseeable. Direct and indirect effects are generally combined together since separation of these effects is often subjective and not warranted for analysis purposes. NEPA requires consideration of “the relationship between short-term uses of man's environment and the maintenance and enhancement of long-term productivity" (40 CFR 1502.16). As declared by the Congress, this includes using all practicable means and measures, including financial and technical assistance, in a manner calculated to foster and promote general welfare, to create and maintain conditions under which man and nature can exist in productive harmony, and fulfill the social, economic, and other requirements of present and future generations of Americans (NEPA Section 101).

Spatial and Temporal Context for Effects Analysis

For the purposes of the analysis of direct/indirect and cumulative effects, short-term effects are those lasting five years or less whereas those effects lasting longer than this are considered to be long-term effects. The time period for short-term effects is based on information from the Beaver Creek experimental watershed in northern Arizona indicating that suspended sediment concentrations in a catchment that was clear cut stabilized approximately five years following treatment (Hansen, 1965). This finding is consistent with field observations by resource specialists indicating that within approximately five years of thinning treatments, vegetative cover is restored to pre-disturbance levels (Steinke, personal communication, 2013).

Direct/indirect and cumulative effects to soils, springs, wetlands, and riparian areas are analyzed within the proposed project boundary since any impact to these resources by proposed treatments would most likely occur at or in their immediate vicinity. For example, soils are most likely to be impacted by those activities that occur directly on them as opposed to activities that are distant from the soil resource. In the case of water quality, direct/indirect and cumulative effects are analyzed at the catchment scale. Catchments are drainage areas nested within larger sub-watersheds and are an appropriate analysis scale for this project as impacts to water quality from proposed vegetation treatments and past, present, and reasonably foreseeable future actions are most likely to be detectable at this scale rather than at the larger sub-watershed scale, in which catchments are nested.

Connected Actions, Past, Present, and Foreseeable Activities Relevant to Cumulative Effects Analysis

Other past, present, and reasonably foreseeable future actions that are likely to cause ground disturbance and therefore contribute to cumulative impacts to soil and water resources generally include timber harvesting, recreation activities, and grazing. Though not a mode of ground disturbance, climate change may also be considered a cumulative effect with potential impacts to soil and water resources. Specifically, the effects to soil and water resources associated with the following projects/activities were considered in the cumulative effects analysis:

- Mountain Elden/Dry Lake Hills (MEDL) Recreation Planning Project

- Eastside Fuels Reduction Project
- Four Forest Restoration Initiative
- Jack Smith Schultz Fuels Reduction Project
- General dispersed recreation activities
- Grazing
- Climate Change

Alternative 1 – No Action

Soils

Direct and Indirect Effects

Under the No Action Alternative, there would be no vegetation treatments to modify stand structure in order to reduce the risk of wildfire and/or its intensity should a wildfire occur within the analysis area. The majority of the DLH and MM portions of the analysis area are classified as having a group I natural fire regime, which is generally characterized by low-severity fires replacing less than 25 percent of the dominant overstory vegetation but can include mixed-severity fires that replace up to 75 percent of the overstory.

In turn, the condition class for the majority of these areas, which reflects the extent to which current vegetation (in terms of composition and structure) departs from simulated historic vegetation reference conditions due to an absence of fire and an increase in fire return intervals for a particular natural fire regime, is condition class 3, reflecting a high departure from reference conditions. This high departure from natural (reference) conditions highlights the vulnerability of the catchments draining the analysis area to a fire that would likely greatly alter the catchment hydrologic response, rate of erosion, and sediment transport.

This alternative would not authorize ground disturbance from mechanical vegetation and prescribed fire treatment activities. As a result, there would be no risk to soil productivity from disturbance associated with these activities. Soil resources, however, would continue to be at risk from a wildfire as noted below.

Fire suppression and historic grazing combined with subsequent favorable weather conditions for pine recruitment have been identified as causative factors in the high densities of trees in southwestern ponderosa pine forests under post-European settlement conditions (Covington, et.al., 1997). The high canopy cover in these forests has reduced understory shrub and herbaceous species leading, in some cases, to monoculture stands of stunted ponderosa pines. Under the No Action Alternative, the current forest structure would remain unaltered. The density of forest overstory cover would remain higher than historic evidence suggests it was and herbaceous and shrub species would continue to be suppressed. The risk of stand-replacing fires would remain elevated. These “no action” conditions have important consequences to soil resources.

The likelihood of a stand-replacing fire under the current (no action) forest structure poses a serious risk to soil condition. Since there would be no vegetation treatments authorized under the No Action Alternative, forest soils in untreated areas would potentially be vulnerable to the effects of an uncharacteristic stand-replacing wildfire given the departure of existing forest conditions from reference conditions. Such a fire occurred on the Coconino National Forest in June 2010 during the Schultz Fire. The Schultz Fire burned approximately 15,000 acres with roughly 39 percent of the area classified as high burn severity and 27 percent as moderate burn severity (Higginson, 2010). These types of fires can result in large losses of soil nutrients through volatilization, mineralization, and subsequent accelerated erosion (Neary, et.al., 1999).

In addition, adverse impacts to soil hydrologic functioning (i.e., reduced infiltration through consumption of soil organic matter, loss of soil structure, and formation of soil hydrophobicity) can occur (Neary, et.al., 1999). .

In order to make predictions about the potential consequences to soils from the no action alternative and compare these consequences to the proposed action alternatives, soil burn severity maps were generated from simulated wildfire in the project area. Soil burn severity has been identified as a key indicator of the susceptibility of a burned area to accelerated erosion and flooding and, consequently, soil burn severity categories are used to determine appropriate soil and hydrologic parameters needed for post-fire runoff and erosion modeling. For this project, soil burn severity maps were generated for the no action alternative as well as alternatives 2 and 4 for the Dry Lake Hills and Mormon Mountain areas using output values from simulated fire behavior modeling runs conducted for the various alternatives for both project areas. The simulated fire behavior modeling conducted for this project is described in the Fire Specialist Report. A soil burn severity map was not generated for alternative 3 since the proposed total treated area and type of treatments are similar enough to alternative 2 that post-treatment fuel conditions and simulated wildfire behavior would be not be substantially different. The specific fire behavior model output used as a metric for soil burn severity was heat/unit area (HUA) expressed in units of kilojoules/m^2 (kJ/m^2). Using rules developed by the project fire ecologist, HUA values were further adjusted to account for conditional crown fire, which is a crown fire that moves through the crown of trees but is not linked to a surface fire. HUA values corresponding to high, moderate, low, and very low/unburned soil burn severity categories were determined by adjusting the minimum HUA value for each soil burn severity category to achieve the same percentage of soil burn severities for the DLH area under the no action alternative condition as was mapped for the Schultz fire. Based on this, minimum HUA values for soil burn severity categories of high, moderate, low, and very low/unburned were determined to be 60,313 kJ/m^2, 8,655 kJ/m^2, and 4,594 kJ/m^2, respectively. These minimum values were then used to create soil burn severity maps for alternatives 2 and 4 in the DLH area and for the no action alternative, alternative 2, and alternative 4 in the Mormon Mountain area as graphically depicted in figures 12 through 17 and tabularly depicted in tables X and X. This process resulted in a higher percentage of the Mormon Mountain area being classified as "high soil burn severity" under the no action alternative than for the DLH area. Though the Schultz fire with its known soil burn severity distribution, proximity to the DHL area, and similar fuel load conditions served to calibrate HUA values to soil burn severity categories for the DLH area under the no action alternative, a similar situation did not exist for the Mormon Mountain area. It is not certain that HUA values used to categorize soil burn severity for the DLH area are applicable to the Mormon Mountain area, however; a higher percentage of high soil burn severity would be expected from a wildfire burning through the Mormon Mountain area given the fuel load and fuel type conditions in this area.

Table 1 - Soil Burn Severity Categories as a Percentage of Simulated Wildfire Area, Dry Lake Hills

	Soil Burn Severity (% of total simulated fire area)			
Alternative	unburned	low	moderate	high
No Action	9	27	25	39
Alternative 2	37	41	14	8
Alternative 4	21	31	18	30

Table 2 - Soil Burn Severity Categories as a Percentage of Simulated Wildfire Area, Mormon Mountain

	Soil Burn Severity (% of total simulated fire)			
Alternative	unburned	low	moderate	high
No Action	1	15	22	62
Alternative 2	32	36	31	1
Alternative 4	37	31	16	17

Figure 12 – Soil Burn Severity Map for Dry Lake Hills for the No Action Alternative with Simulated Wildfire

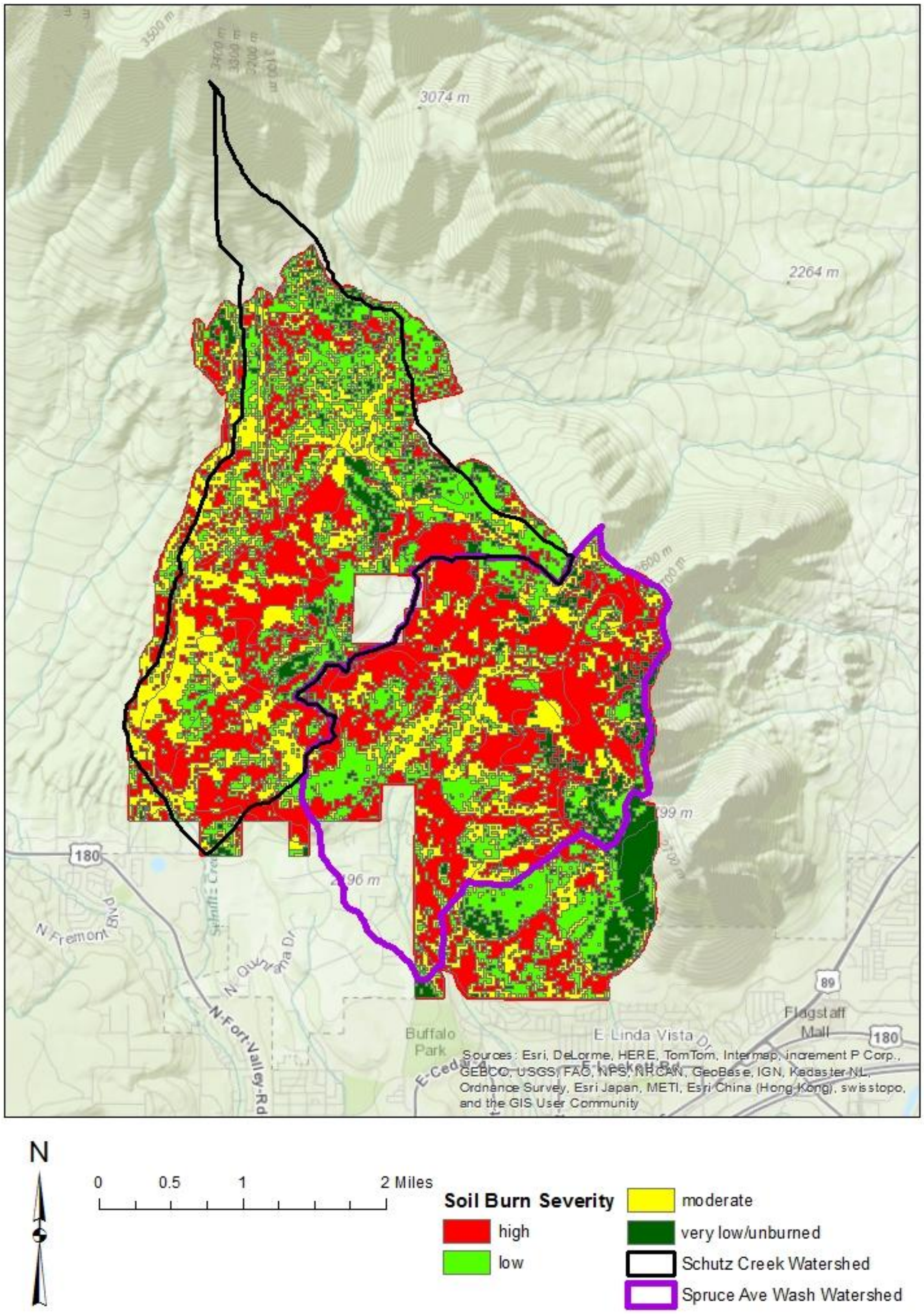


Figure 13 – Soil Burn Severity Map for Dry Lake Hills for Alternative 2 with Simulated Wildfire

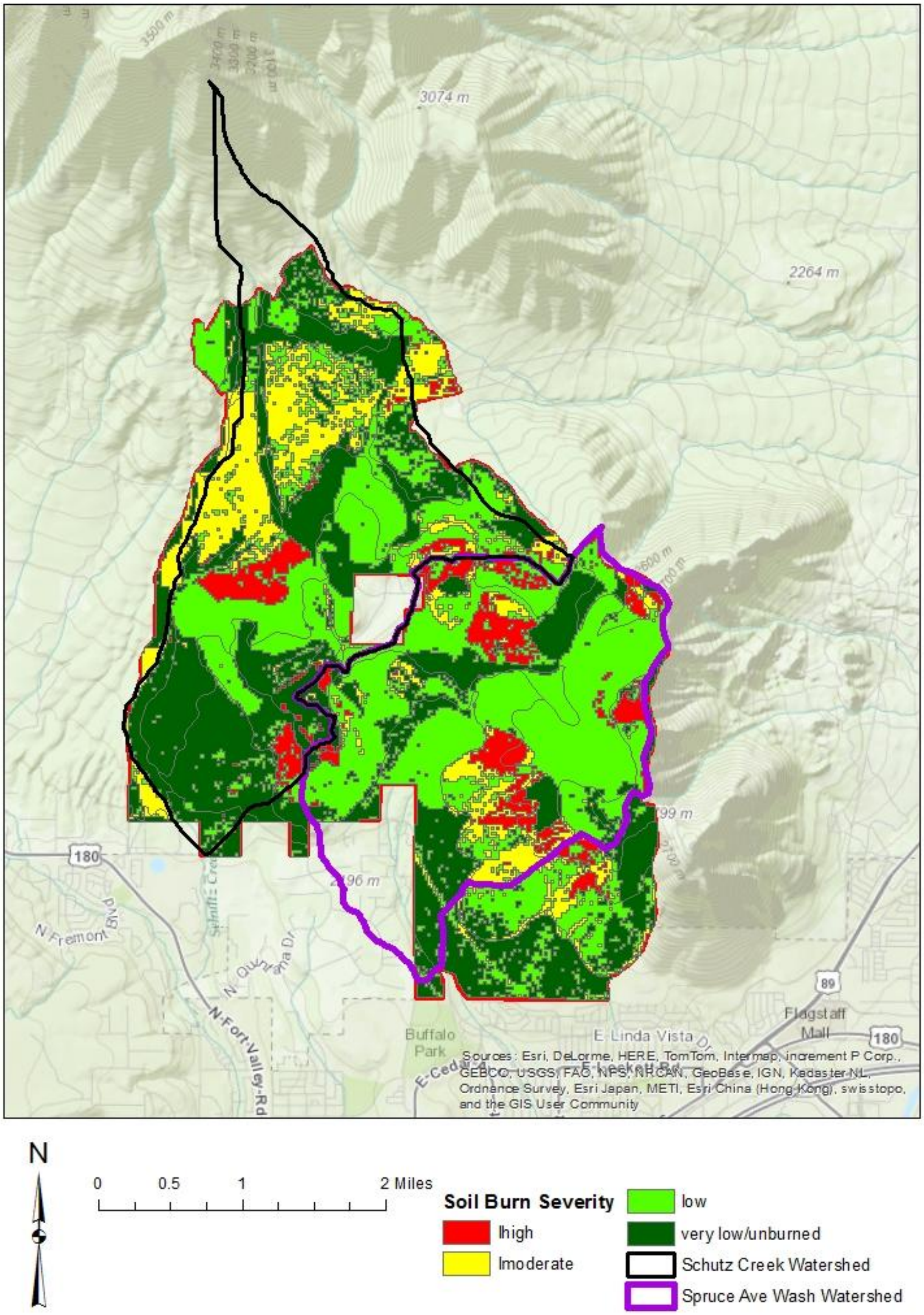


Figure 14 – Soil Burn Severity Map for Dry Lake Hills for Alternative 4 with Simulated Wildfire

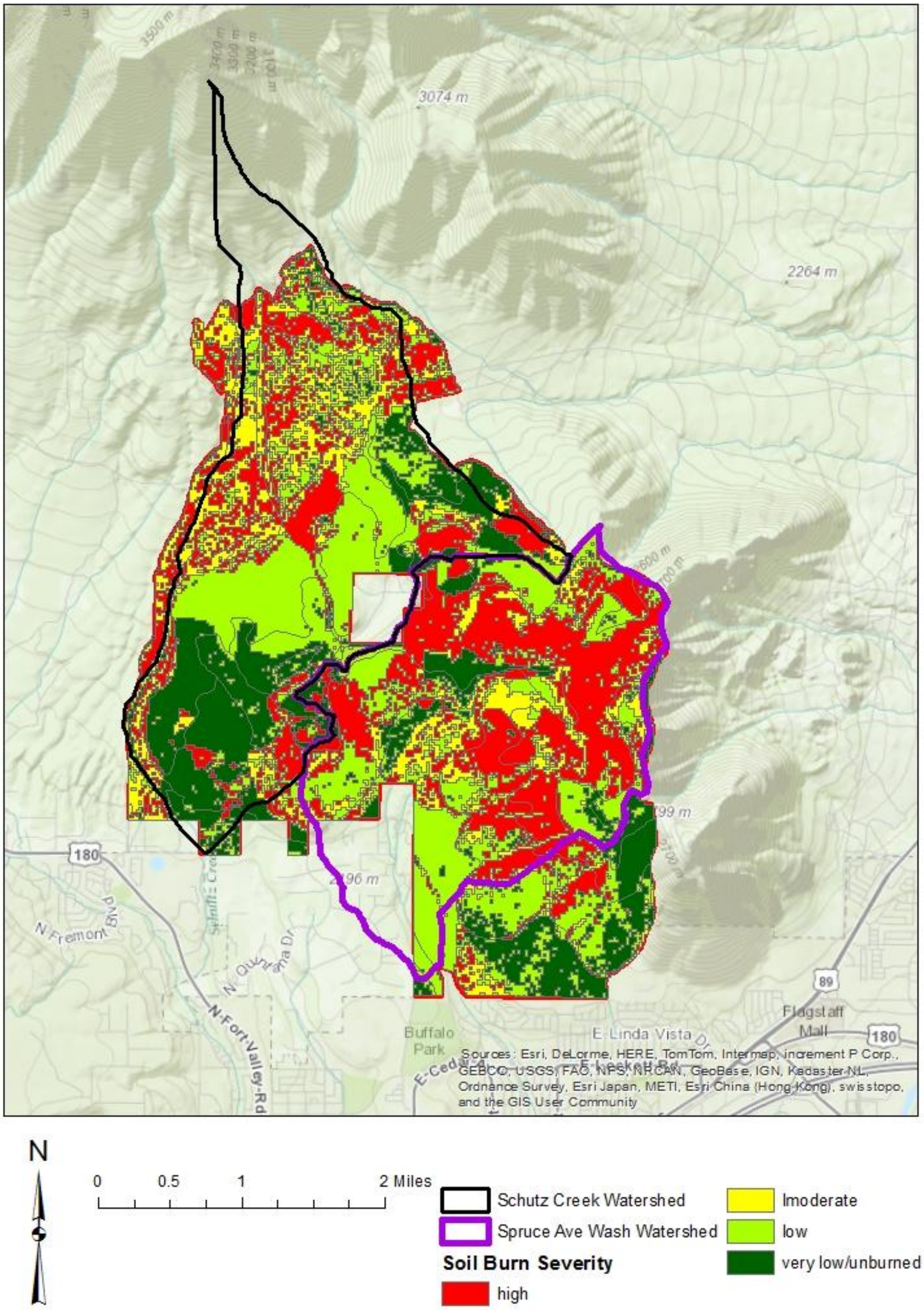


Figure 15 – Soil Burn Severity Map for Mormon Mountain area for the No Action Alternative with Simulated Wildfire

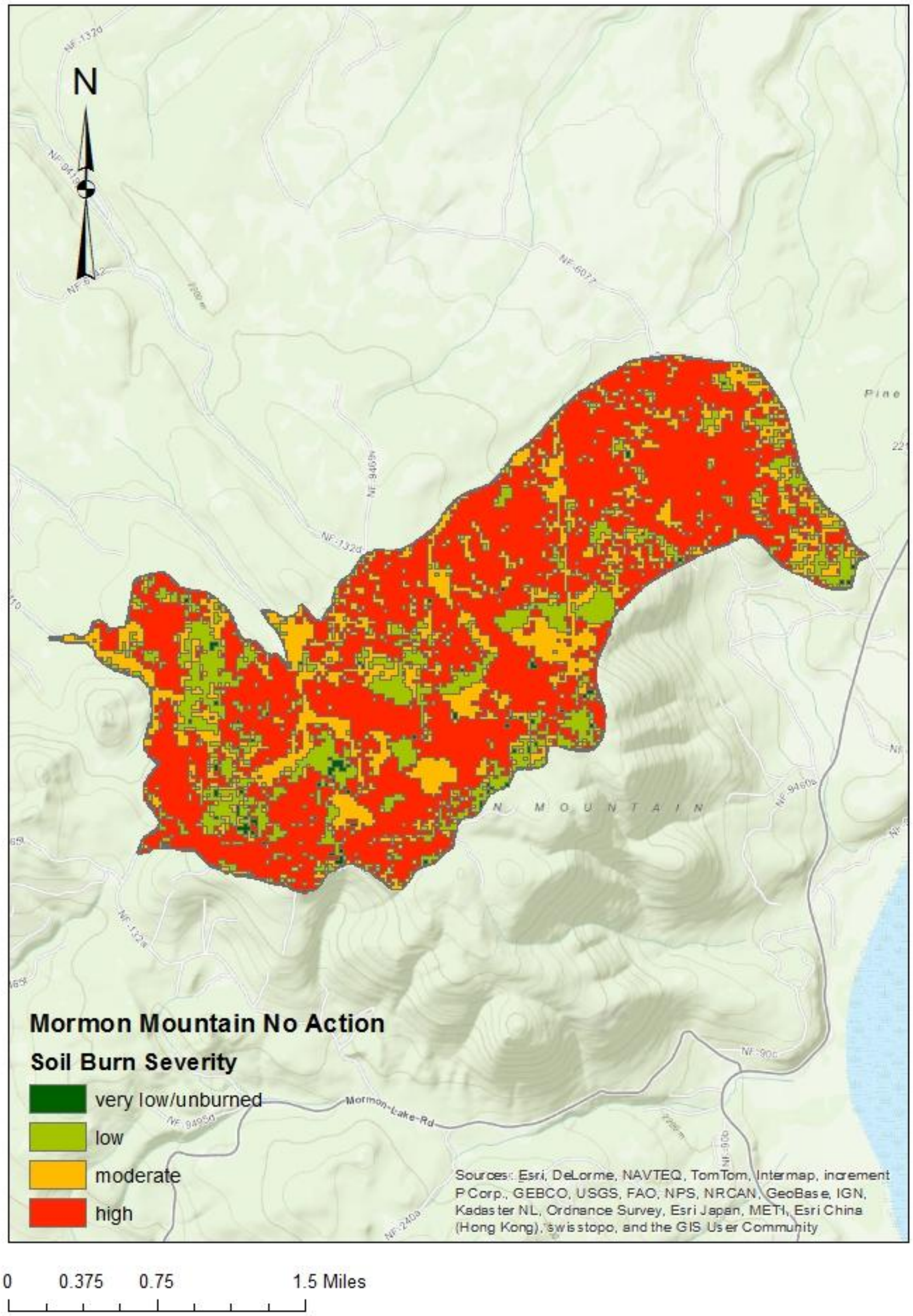


Figure 16 – Soil Burn Severity Map for Mormon Mountain area for the Alternative 2 with Simulated Wildfire

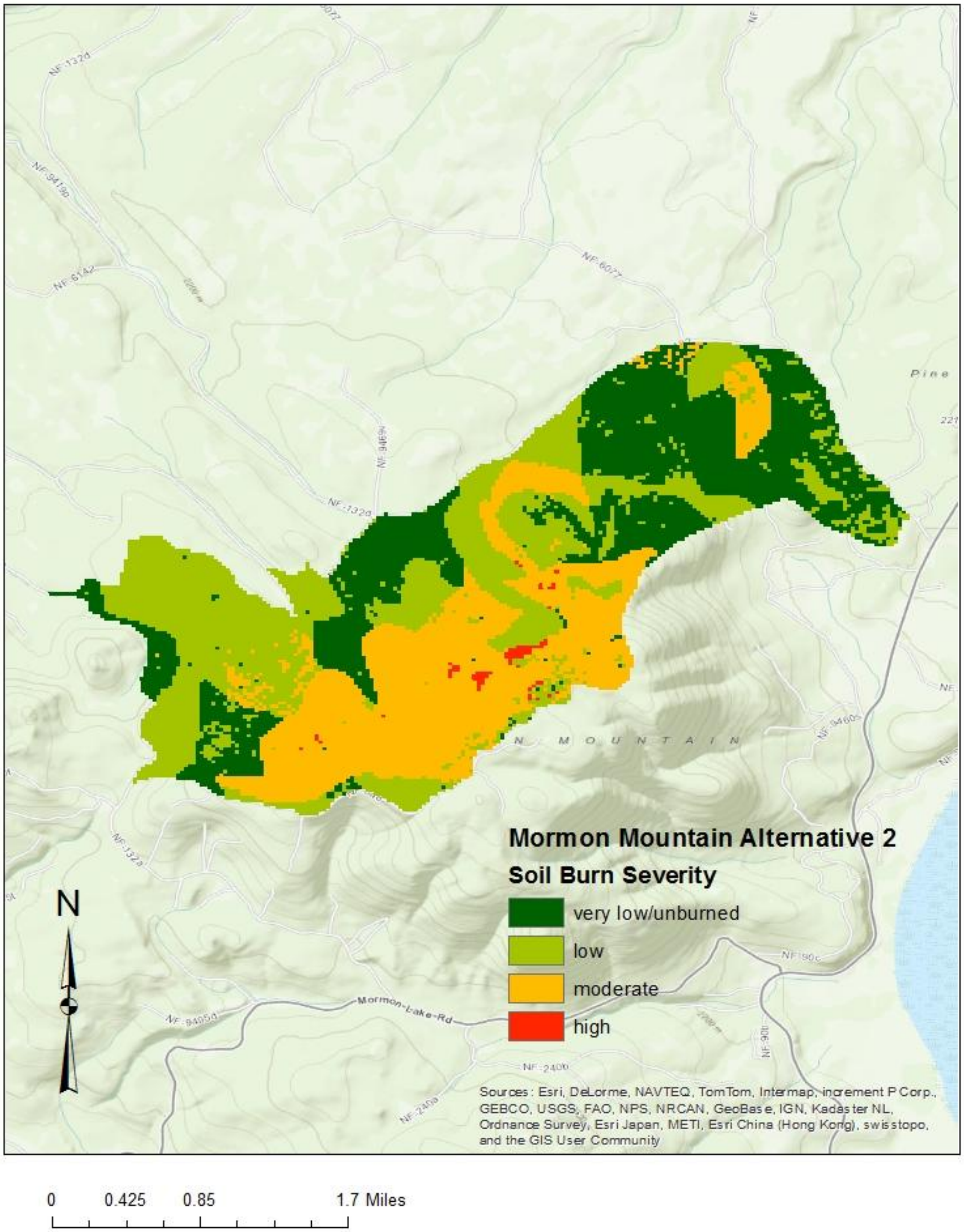
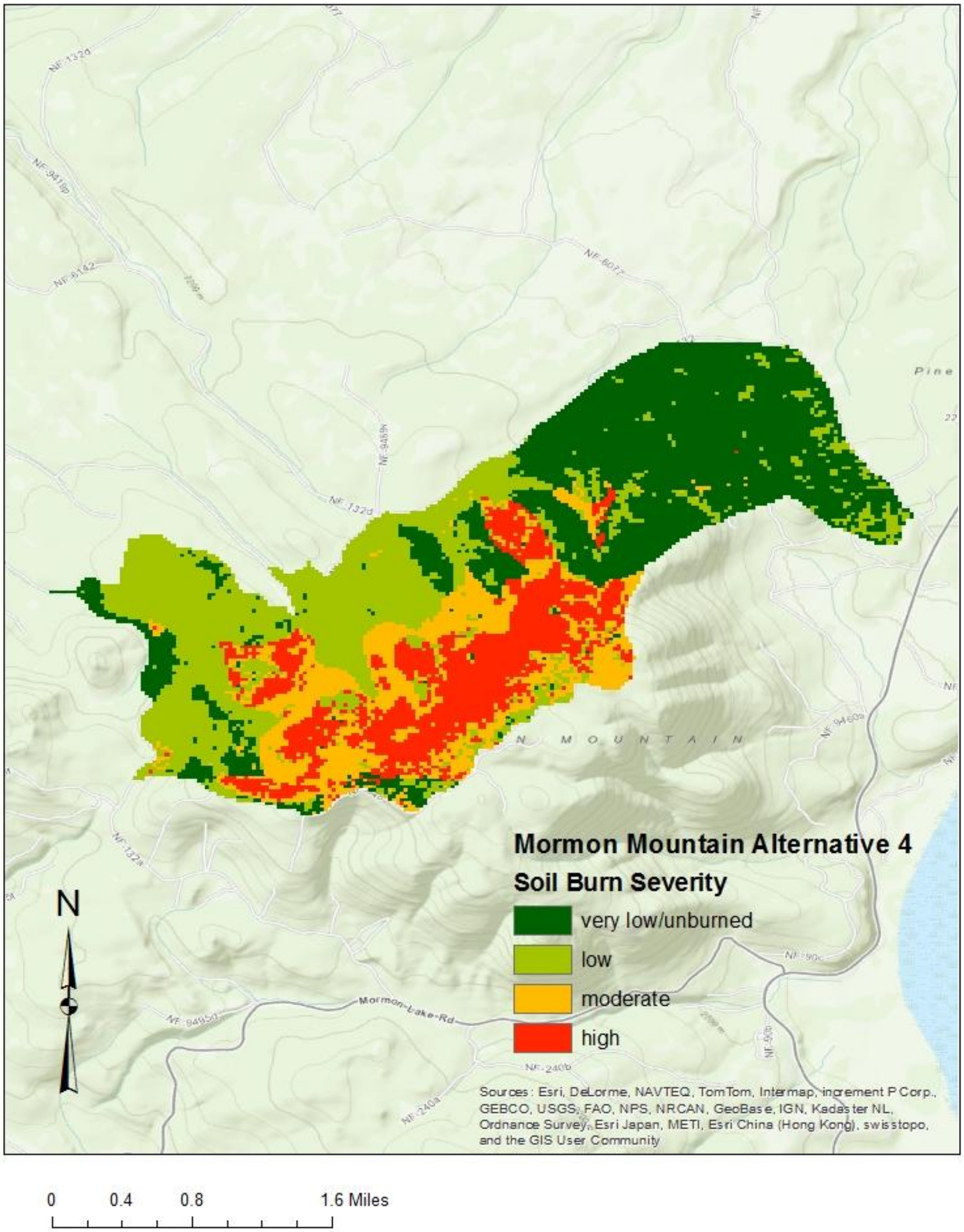


Figure 17 – Soil Burn Severity Map for Mormon Mountain area for the Alternative 4 with Simulated Wildfire



Post-simulated wildfire hillslope erosion predictions for untreated and treated forest conditions were made using the web-based Erosion Risk Management Tool (ERMiT) without consideration of potential Burned Area Emergency Response (BAER) treatments that would potentially be implemented following a wildfire of the size simulated. BAER treatments were not considered as there is no way to predict the type or quantity of treatments that would potentially be implemented. This on-line tool (http://forest.moscowfsl.wsu.edu/cgi-bin/fswepp/ermit/ermit.pl) was developed by the U.S. Forest Service based on Water Erosion Prediction Project (WEPP) technology specifically for predicting erosion rates on hillslopes following a wildfire (Robichaud, et. al ., 2007). This tool specifically predicts post-fire sediment delivery rates to streamcourses from rill and interrill erosion processes occurring on hillslopes that drain to these streamcourses. Hillslopes and streamcourses were delineated with ArcGIS 10.1 using a 10-meter digital elevation model. This delineation resulted in 835 separate hillslopes in the DLH area and 274 separate hillslopes in the Mormon Mountain area. ERMiT input parameters of soil texture and soil burn severity classification were derived from TES and the soil burn severity maps, respectively. ERMiT climate input data for the DLH area was derived from a weather station located at the Fort Valley Experimental Forest headquarters on State Highway 180 whereas climate data for the Mormon Moutain area was derived from a weather station at the Flagstaff airport. Hillslopes with surfaces mapped as rock outcrop were considered to be non-erodible whereas sediment delivery from very low/unburned hillslopes was assumed to be zero based on reported erosion rates for undisturbed forest conditions (Elliot and Robichaud, 2005).

Rather than absolute values reflecting average erosion rates for a specified period, ERMiT sediment delivery predictions are presented in probabilistic terms. For example, a sediment delivery rate based on a probability of 50% means that this sediment delivery rate has a 50% chance of being equaled or exceeded in a given year. This approach to prediction is in part, a function of the probabilities associated with various sized rainfall and associated runoff events based on a statistical analysis of historic weather records. Tables 2 and 3 are summaries of the total predicted sediment delivery to streamcourses from hillslope erosion processes within the DLH and Mormon Mountain areas for the first year following simulated wildfire based on a 50% probability that these values would be equaled or exceeded during this first year. The % change in sediment delivery represents a comparison between sediment delivery under the no action alternative versus alternatives 2 and 4 with negative values indicative of a decrease in total sediment delivery. Because of the variabilities in soil properties, soil burn severities, and climate at the hillslope scale, the values presented in table 2 should not be viewed as absolutes but rather, should be viewed as relative values allowing a comparison between the alternatives.

Table 2 – Summary of Total Sediment Delivered to Stream Network in DLH area During First Year Following a Simulated Wildfire

Alternative	Total Sediment Delivery (tons)	% Sediment Delivery Change
No Action	14,912	0
Alternative 2	8,277	-44
Alternative 4	12,977	-13

Table 3 – Summary of Total Sediment Delivered to Stream Network in Mormon Mountain area During First Year Following a Simulated Wildfire

Alternative	Total Sediment Delivery (tons)	% Sediment Delivery Change
No Action	2,445	0
Alternative 2	1,432	-41
Alternative 4	1,551	-37

These results suggest that thinning treatments proposed under alternative 2 provide the greatest benefits in terms of mitigating the potential threat from erosion associated with a wildfire.

Cumulative Effects

In addition of those direct/indirect effects to soils from the No Action Alternative, particularly, the continuation of forest conditions conducive to an uncharacteristic wildfire, the following cumulative effects to soils from past, present, and reasonably foreseeable future projects would potentially occur.

The MEDL Recreation Planning Project currently proposes roughly 30 miles of new or re-located trails; consolidation, re-location, or expansion of existing trailheads; construction of a hang glider launch pad; and establishment of new trailheads with associated parking areas either within or immediately adjacent to the analysis area. This project would address increasing demand for recreational opportunities in the Flagstaff area by providing a sustainable trail system to accommodate multiple user groups including hikers, mountain bikers, horseback riders, climbers, and hang gliders. Even though there would be additional impacts to soils associated with new trail construction, new or expanded trailhead parking areas, and a hang glider launch pad, the project would likely have an overall positive impact on soils since it would re-route those trails that cannot be adequately drained because of their position on the landscape, it would include the decommissioning of non-system trails and roads, and it would consolidate several trailheads. Those portions of non-system trails that meet Forest Service trail construction standards would be incorporated into the system of new trails thereby further reducing new disturbance to soils.

The Eastside Fuels Reduction Project (2009) is an ongoing effort to reduce hazardous fuels around the base of Mt Elden involving approximately 226 acres of hand thinning, 151 acres of ground-based mechanical thinning on slopes less than 40 percent, and 56 acres of burn only (prescribed fire) treatment within the DLH area. The Jack Smith Schultz Fuels Reduction Project (2008), located within the DLH area, is a hazardous fuels reduction project in the DLH area that includes burn only treatments, mechanized ground-based harvesting on slopes less than 40 percent, and hand-thinning treatments. Potentially beginning in 2014, a 837 acre portion of the DLH area would be treated as part of the future Orion Timber Sale included within the Jack Smith Schultz Fuels Reduction Project. This area would be treated by ground-based harvesting on slopes less than 40 percent with the effects to soils as described in the section on effects common to all action alternatives. Mechanized, ground-based tinning and prescribed fire treatments would cause disturbances to soils with erosion rates likely exceeding rates under undisturbed forest conditions for the short term; however, similar mitigation measures as proposed for action alternatives would be implemented minimizing the amount of disturbance to soils. It is important to note that some amount of disturbance to soils can be beneficial as it promotes the spread of herbaceous cover that can improve nutrient cycling and soil stability. The reduction in hazardous fuels would also reduce the likelihood of an uncharacteristic wildfire with its consequent impacts to forest soils.

There are no past, present, or reasonably forseeable future vegetation treatments within the MM area, but recreation activities, including but not limited to hiking, mountain biking, and hunting have occurred and would continue to occur within this portion of the analysis area. These activities affect soils because they typically require a network of roads and trails resulting in the reduction or elimination of vegetative cover and compaction of soils, both of which can lead to accelerated erosion.

The current road system in the MM area includes 30.2 miles of roads open to the public, 8.9 miles of roads closed except for limited administrative use, and 1.6 miles of roads closed to all uses. Roads open to the public are typically only seasonally accessible because of snow accumulation. Roughly one-third of a mile of the Arizona Trail crosses the northeastern corner of the project area. Except in localized segments, these roads are not likely to be experiencing accelerated erosion because of low or no traffic and limited maintenance both of which are factors that affect road erosion rates (Grace and Clinton, 2007). Under low or no traffic conditions, road surfaces may become armored, reducing erosion rates by 70 to 80 percent (Elliot, et.al., 2009).

The Peaks Allotment overlaps the DLH-portion of the project area and includes portions of two grazing pastures; Freidlein Prairie and Schultz. Neither pasture has been grazed in over ten years and are deferred from livestock use indefinitely per the August 19, 2010 Decision Notice/FONSI for the Peaks Allotment.

Two grazing allotments, Tinny Springs and Picket Lake/Padre Canyon overlap the MM-portion of the project area. These allotments are grazed from June 1 through October 31, in the case of Tinny Springs, and June 1 through September 30, in the case of Picket Lake/Padre Canyon. Grazing can affect soils through removal of vegetation and compaction of soils, however; these effects are often temporary with recovery of vegetation following precipitation and recovery of soil compaction through natural soil disturbance mechanisms such as heaving of soils freeze/thaw cycles and burrowing of animals. The transient disturbance to soils from cattle grazing is not expected to result in negative impacts to soil productivity even when combined with other disturbances to soils as discussed in this section.

The extent to which climate change impacts soil productivity would be largely governed by the impact of climate change on vegetation structure and composition. Vegetative cover fluctuates naturally in response to inter-annual and longer climate variability. Climate change in the North American southwest is predicted to lead to decreased winter precipitation throughout the current century (Seager and Vecchi, 2010). This decline in winter precipitation could lead to a decrease in herbaceous cover dependent on winter precipitation. Although winter precipitation is important for annuals and cool season grasses as well as replenishment of soil moisture, herbaceous productivity in the southwest is primarily controlled by summer precipitation delivered by the North American monsoon (NAM) (McCollum, et.al., 2011). The effect of climate change on the NAM, which accounts for roughly half the precipitation in the region, is uncertain, however; recent research suggests a delay in the onset of the NAM with no change in total precipitation http://www.ldeo.columbia.edu/res/div/ocp/glodech/research10futureANM.html). A delay in NAM would increase the length of the fire season potentially leading to more severe and widespread forest fires. It is this potential effect of climate change that would pose the greatest threat to soil productivity likely overwhelming any other cumulative effects to soils within the project area. Under the no action alternative, risks to soils from climate change-induced increases to fire severity and size would not be reduced.

Water Quality

Direct and Indirect Effects –

Under the No Action Alternative, water resources would not be affected by the proposed treatments included in the action alternatives as no actions would be authorized. However water resources would potentially be affected by the failure to reduce current fuel load conditions that are conducive to an uncharacteristic stand-replacing wildfire. In particular, the potential for a wildfire similar to the Schulz Fire that occurred in 2010 would still exist. This wildfire resulted in an increase in the amount of rainfall converted to runoff producing widespread flooding, incision of existing drainages, erosion of hillslopes, and mobilization of sediment. Post-fire peak discharges were estimated to be one to two orders of magnitude larger than those produced by similar pre-fire rainfall events (Neary, et.al. 2012). If a similar fire were to occur in the DLH-portion of the analysis area, flooding would likely occur in heavily populated portions of the City of Flagstaff along the Rio De Flag and Spruce Avenue Wash/Switzer Canyon drainages. In particular, the Rio De Flag has been the subject of a feasibility study to improve flood protection along this drainage as the "economic, social, environmental, and regional impacts and damages from a large flood event would be severe and devastating to the community" (USACE, 2000).

An uncharacteristic stand-replacing wildfire in the MM-portion of the analysis area would potentially impact water quality in Upper Lake Mary, the principal source of surface water for the City of Flagstaff. A comparison of the amount of sediment that could be delivered to streamcourses from hillslope erosion within a one year period following ground-based mechanized thinning treatments, thinning treatments combined with prescribed fire, and wildfire was simulated by Elliot and Robichaud (2001) using Disturbed WEPP, an Internet-based computer program designed to predict runoff and rill/interrill erosion from undisturbed forests, forest fires (prescribed and wild), forests disturbed by timber harvesting, and rangelands under various cover conditions. Sediment yield was predicted to be 0.033 tons/hectare for first year following thinning treatments alone, 0.11 tons/hectare for thinning combined with prescribed fire, and 8.93 tons/hectare for wildfire. These simulation results highlight the increase in erosion following wildfire versus that from vegetation treatment. When compared to natural rates of erosion in forest environments, which have been reported to be less than 0.11 tons/hectare (Elliot, et.al., 1999), it can be seen that thinning or thinning combined with prescribed fire is not likely to increase the amount of sediment reaching streamcourses, but that wildfire may do so by several orders of magnitude.

Hydrologic modeling of the roughly 3,751 acre Schultz Creek watershed (as delineated from the point at which Schultz Creek crosses the Mt Elden Lookout Road) was conducted in order to compare predicted total runoff and peak discharge following a simulated wildfire followed by various precipitation events for the no action alternative, alternative 2 and alternative 4. Modeling was conducted using WildCat5, a hydrologic model for predicting total runoff and peak discharge for single rain events based on the curve number (CN) method developed by the former U.S. Soil Conservation Service (now USDA-Natural ResoucesConservationService). The CN method requires the classification of soils into different hydrologic soil groups (i.e., A, B, C, and D) based on their minimum infiltration rate as well as selection of representative CNs. Soils were placed into different hydrologic soil groups (HSGs) based on soils information contained in the Terrestrial Ecosystem (TES) survey for the Coconino National Forest. CNs are coefficients representing the effects of land use/cover, soil type, and surface cover condition on the runoff response and generally range from a low of 25 for forested lands with soils completely covered by living or dead biomass to a high of 98 for impervious areas such as parking lots. Representative CNs for the various hydrologic soil groups (HSGs) under current conditions were initially selected from published literature (SCS, 1986) but were subsequently adjusted to generate a peak discharge similar to that identified by FEMA for the 1% recurrence interval event (100-year flood) for Schultz Creek (FEMA, 2010). Post-fire CNs based on soil burn severity and HSG were derived from values used for post-Schultz fire flood estimation without adjusting for slope. Fire model outputs were not available for roughly 430 acres within the Schultz Creek watershed as can be seen as uncolored areas on the soil burn severity maps. In these areas, CNs were selected to represent unburned forest conditions. Modeling runs were conducted for the 100-year precipitation event as well as a precipitation event that occurred over the area impacted by the Schultz fire on July 20, 2010 as summarized in table 1. This type of high-intensity, short-duration rain event is much more likely than the statistically rare 100-year event that has only a 1% chance of occurring in any given year. Modeling runs for the various action alternatives in the absence of wildfire were not conducted because there is no meaningful method for estimating curve numbers under the spatially varied disturbance that is typical of fuel treatments. Thinning treatments may locally alter surface cover and soil infiltration rates but these areas of disturbance are likely to be surrounded by undisturbed areas which act as buffers for absorbing runoff.

Table 1 – Predicted Peak Discharges for Schultz Creek at Mt Elden Lookout Road

Alternative	FEMA 100-year Peak Discharge (cfs)	100-year Peak Discharge (cfs)	Schultz Rain Event Peak Discharge (cfs)
No Action, Current Conditions (no wildfire)	440	474	222
No Action, Simulated Wildfire	Not Available	2045	2014
Alternative 2, Simulated Wildfire	Not Available	1184	804
Alternative 4, Simulated Wildfire	Not Available	1607	1409

Notes
1. 100-year storm even equates to 4.98 inches of rain in a single day.
2. Schultz rain event equates to rain event on July 20, 2010
which dropped 1.78 inches of rain in 45 minutes over area

The predicted Schultz Creek peak discharge under the no action alternative with simulated wildfire was roughly 4.3 times the predicted 100-year peak discharge under current conditions (i.e., no fuel treatments or wildfire). The predicted peak discharge for alternative 2 with simulated wildfire was roughly 2.5 times the predicted 100-year peak discharge under current conditions whereas the predicted peak discharge for alternative 4 with simulated wildfire was roughly 3.4 times the predicted 100-year peak discharge under current conditions. These results suggest that thinning treatments proposed under alternative 2 provide the greatest benefits in terms of mitigating the potential threat from flooding associated with a wildfire. Although hydrologic modeling was not conducted for Spruce Avenue Wash, which drains the eastern portion of the project area, the conclusions would likely be similar based on the difference in soil burn severities under the various alternatives.

Cumulative Effects

The cumulative effects of vegetation treatment activities associated with the Jack Smith Schultz and Eastside Fuels Reduction projects as well as the MEDL Recreation Planning project may lead to short-term increases in the delivery of sediment to streamcourses within the catchments of the DLH area, however, these increases are likely to be small and not detectable at catchment outlets given the ephemeral nature of flow in these streamcourses, the spatial and temporal aspects of disturbance, and the length of time, measured in years to decades, it takes for sediment to be routed through a forest streamcourse (see

Table 7; Elliot and Robichaud, 2005). Typical erosion and sediment delivery rates for forest disturbances are presented below. Also, recovery from even extreme disturbance events in forests, even wildfire, is typically rapid with rates of erosion reported to drop by up to two orders of magnitude in the second year following a wildfire and returning to natural (undisturbed) rates in the fourth year following a wildfire (Robichaud and Brown, 1999). Because disturbance activities would be distributed in both space and time rather than simultaneously and concentrated, the cumulative effects to water quality are predicted to be insignificant.

Table 7: Predicted rates of erosion (from Elliot and Robichaud, 2005)

Erosion Disturbance	**rate**	**Time between disturbances**	**Average annual sediment delivery**
	Mg/ha	*years*	*Mg/ha*
Wildfire	6.0	40	0.15
Prescribed fire	0.02	20	0.001
Thinning or	0.10	20	0.005
Road segments (assuming 2.5% of watershed)	0.125	1	0.125

Within the catchments draining the MM area, cumulative effects to water quality could occur by implementation of mechanical treatments under the Four Forests Restoration Initiative (4FRI) combined with those from the road system within the catchments. It is not predicted that grazing within the catchments would negatively impact water quality. Since roads within the catchments are only seasonally accessible with low traffic conditions and low maintenance activities, two conditions that strongly influence rates of erosion on forested roads (Grace and Clinton, 2005), combined with streamcourses that flow only intermittently mainly following spring snowmelt, the existing road system is not likely to be contributing significantly to water quality degradation in Lake Mary. Vegetation treatment activities within the catchments associated with 4FRI would likely occur over a period of years, resulting in temporally varied disturbance to forest soils with minimal sediment delivery to streamcourses within any given year. The temporary disturbance to forest soils with short-term increases in erosion rates and delivery of sediment to streamcourses contrasts with the potential impacts to the water quality of Upper Lake Mary from an uncharacteristic wildfire that would dramatically increase rates of erosion and the delivery of sediment and ash to this water body.

Effects Common to All Action Alternatives

Soils

Direct and Indirect Effects to Soils

The three action alternatives all include burn only treatments, hand thinning treatments, and mechanized thinning treatments on slopes less than 40 percent. In addition, prescribed burning would be performed after the various thinning treatments. This section provides an overview of the potential effects to soils and water resources from these treatments.

Table 8 provides a summary of the various treatment methods proposed under each alternative with thinning treatments organized by method of felling and yarding.

Table 8: Summary of Proposed Vegetative Treatments by Alternative

			TREATMENT METHOD AREA (acres)							
Action Alternative	No Treatment	Burn Only	Hand Thinning/ No Yarding	Mechanized Thinning and Yarding (slopes less than 40%)	Mechanized Thinning and Yarding (slopes greater than 40%)	Mechanized or Hand Thinning/ Excaliner Yarding	Mechanized or Hand Thinning/ Skyline Yarding	Mechanized or Hand Thinning/ Helicopter Yarding	Mechanized Harvesting/ No Yarding	TOTALS
2 - DLH	1606	568	715	3496	0	594	575	0	15	7569
3 - DLH	1606	568	653	3496	273	0	0	973	0	7569
4 - DLH	4110	67	438	2954	0	0	0	0	0	7569
2 - MM	0	402	147	2320	0	33	73	0	0	2975
3 - MM	0	402	180	2320	73	0	0	0	0	2975
4 - MM	631	34	0	2310	0	0	0	0	0	2975
TOTALS										
Notes:										
1 - No treatment in the DLH area includes roughly 837 acres of mechanized thinning on slopes less than 40% that will be treated										
as part of the Orion Timber Sale. This area has already been analyzed as part of a separate NEPA decision.										
2 - Due to rounding of numbers, treatment areas may differ between specialist reports and between alternatives.										

Hand Thinning

A minor amount of hand thinning using chainsaws and hand piling of downed material with no yarding of felled timber would be implemented in the various action alternatives. Hand thinning would result in minimal impacts to soils since no construction of temporary roads would be needed, and heavy machines would not be used for felling and transporting of harvested timber. Soil disturbance from hand thinning operations is generally considered negligible (Robichaud, et.al., 2005; Berg and Azuma, 2010). No long-term loss of soil productivity nor accelerated erosion would be expected to occur from hand thinning and hand piling operations.

Ground-based Mechanized Thinning

The majority of the analysis area (roughly 55 percent for Alternatives 2 and 3 and 50 percent for Alternative 4) would be treated by mechanized, ground-based harvesting and yarding methods on slopes less than 40 percent. Ground-based harvesting involves the use of either wheeled or tracked machinery in contact with the ground surface to both cut trees and remove them from the harvest area to landings in a process called “yarding.” Ground-based harvesting systems include whole tree harvesting systems in which trees are felled and the entire tree is skidded from the harvest area to landings, where the trees are further processed by delimbing and bucking (i.e., cutting the trees to specific lengths) and cut-to-length systems in which trees are felled and processed at the stump with transport of processed logs to landings. In whole tree harvesting, trees are generally felled and bunched using a tracked or rubber-tired feller-buncher and tree bunches are skidded (i.e., dragged with crowns in contact with the ground) along designated skid trails to landings. Skidding is generally accomplished using tracked or rubber-tired skidders. In cut-to-length systems, trees are generally felled using a harvester equipped with a head that allows both cutting and processing of trees. Logs are then transported to landings using a forwarder that carries the logs fully suspended from the ground in a trailer-type fashion. Occasionally, harvesting and forwarding is accomplished with a single piece of equipment referred to as a “harwarder.” There are various types of harvesters including trackhoes fitted with processing heads as well as multi-wheeled machines that are capable of operating on slopes exceeding 40 percent (“Forest Operations Equipment”, retrieved May 22, 2014)

Ground-based mechanized thinning causes disturbance to soils including compaction, displacement of surface soil,rutting, and exposure of bare mineral soil attributable mainly to the network of temporary roads, skid trails, and landings needed to accomplish thinning. These effects have the potential to alter soil productivity, as well as surface runoff and erosion rates, which are normally very low under undisturbed forest conditions (MacDonald and Stednick, 2003). In turn, changes in surface runoff and erosion may have an effect on water quality primarily through increased sediment delivery to stream courses. Despite the use of mechanized equipment for this purpose, the actual felling of trees causes only minor disturbance to soils (MacDonald and Stednick, 2003) and will not be discussed further.

Compaction

Compaction is the process by which soil particles are rearranged resulting in a decrease in void space and a corresponding increase in bulk density (NCASI, 2004). Soils are compacted by repeated passes of mechanical equipment over the forest floor along the designated road and skid trail system and landings established to facilitate harvesting, processing, and transport of logs. The degree of compaction is a function of soil characteristics, soil moisture content, number of machine passes over the soil, and pressure exerted by the machinery. Soils with water content just under field capacity (i.e., the water remaining in soil after gravity drainage) are most susceptible to compaction whereas soils with higher water content are susceptible to displacement generally observed as rutting of the soil (NCASI, 2004). Soil compaction may impact soil productivity by decreasing soil macroporosity, leading to reduced water infiltration and gas exchange important for soil biological activity and oxygen uptake by roots (Han, et.al. 2006. Soil compaction may also impact soil productivity by increasing the resistance of soil to root penetration thereby limiting root growth (Lacey and Ryan, 2000). Reduced infiltration rates attributable to soil compaction may lead to increased runoff and accelerated soil erosion with potential impacts to water quality and soil productivity.

Soil Displacement

Soil displacement is the removal of soil material from one place to another often caused by the skidding of logs or whole trees, scraping with a blade, or the turning of tracks or wheels (Napper, et.al., 2009). The displacement of soil can expose less productive soil horizons and/or those with a different chemistry potentially altering site productivity.

Rutting

Rutting is primarily the deformation of soil by equipment operation under suboptimal soil moisture conditions or on soils with low bearing strength (Napper, et.al., 2009). The formation of ruts can concentrate runoff increasing its velocity and capacity to detach and transport soil particles. Ruts may also disrupt natural runoff patterns from hillslopes.

Soil Exposure

The exposure of bare mineral soil increases the susceptibility of soil to detachment from raindrop impact and sheetflow potentially contributing to accelerated erosion on hillslopes.

Temporary Road Construction

The exposure of bare mineral soil is most pronounced on temporary roads and the road system needed to conduct logging operations has been identified as far overshadowing that from other aspects of treatment operations (Rice, et.al. 1972; Megahan and Kidd, 1972). Table 9 displays the estimated distance of temporary roads that are predicted to be needed to carry out thinning treatments in the action alternatives. Temporary roads are those that are constructed during timber harvesting to facilitate access to timber stands and that are rehabilitated after harvesting by restoring the roadbed to its pre-disturbance condition to the extent possible. Some of the proposed temporary roads would be constructed on existing road prisms that were previous Forest Service system roads. Alternatives 2 and 3 are identical in terms of area treated by thinning but in Alternative 3, helicopter and forwarder yarding replace cable yarding. Because of the difference in yarding methods between the two alternatives, the proposed temporary road distance differs by approximately 4.7 miles. Alternative 4 includes less treated acres than alternatives 2 and 3 and therefore, less distance of temporary roads.

Table 9: Summary of Road Distances for Each Action Alternative

Action Alternative	New Temp Roads (miles)	Temp Roads on Existing Road Prism (miles)	Decom Roads (miles)	Relocate Roads (miles)
2 - DLH	14.6	2.8	0.2	0.5
3 - DLH	9.9	2.8	0.2	0
4 - DLH	9.2	2.8	0.2	0
2 - MM	1.1	2.8	3.7	1.6
3 - MM	0	2.8	3.7	0.6
4 - MM	0	1	3.7	1.6
TOTALS	34.8	15	11.7	4.3
NOTES:				
Road distances are rounded to nearest 0.1 miles.				

Broadcast Burning

Fuel treatments using prescribed fire are proposed under the action alternatives either as “burn only” treatments (i.e. no other method of treatment) or following treatment in areas where it is necessary to reduce the fuel load through either hand or mechanical thinning prior to the introduction of fire. In both cases, the effects are anticipated to be similar since prescribed fire would not likely be introduced for several years following mechanical treatment, when enough fine fuel has accumulated to carry a fire.

The conditions under which prescribed burning would be conducted are generally characterized by high relative humidity, low air temperatures, low fuel loadings, and high fuel moisture. These conditions typically produce low burn severity in which surface litter is only partially consumed. In addition, the timing of controlled burns is such that burns are conducted during fall or spring, when lower ambient temperatures minimize surface litter consumption. Prescribed fires, however, do produce spatial variations in burn severity ranging from high to unburned depending on surface fuel loads. This spatial variability leads to varying runoff and erosion rates (Robichaud, et.al., 2010).

In areas of low to moderate soil burn severitity, only a portion of the surface organic matter is consumed leaving adequate soil cover over much of the burned area. In general, prescribed fire does not cause excessive erosion or sediment transport since soil cover is retained in a discontinuous pattern across the landscape. Because of this, long-term adverse impact to soils are not expected from prescribed fire activities. This conclusion is supported by controlled burning experiments conducted on the Fort Apache Reservation located in the White Mountains of northeastern Arizona, which indicated minimal soil erosion following controlled burning (Weaver, 1952; Cooper, 1961). Cooper (1961) evaluated post-burn erosion on a 35 percent hillslope in the White Mountains and concluded that accelerated erosion attributable to controlled burning could not be considered severe and that the soil appeared to be stabilized within a year of treatment. It was also noted that eroded material was only moved a short distance down slope. Conversely, prescribed burning would be expected to have a long-term benefit to soil resources by reducing the build-up of fuels, and restoring soil nutrient cyling through reduction of overtstory and encouragement of herbaceous cover.

Pile Burning

Burning of slash piles has been shown to negatively affect soil biotic and chemical properties due to intense soil heating (Korb et al, 2004 and Seymour and Tecle, 2005). It can result in soil sterilization, increased erosion risk and an increased risk of invasive and noxious weeds that displace native vegetation. Pile burning sites would constitute a small portion of the project area (i.e., less than 5 percent). Monitoring of these sites for the presence of invasive or noxious weeds following pile burning, and treatment of any infestations found would mitigate most adverse effects to soils caused by pile burning of slash (see the Invasive Plant Species Specialist Report for more information).

Best Management Practices

A number of best management practices (BMPs) would be employed to protect soil resources during vegetation treatments. BMPs that would be implemented for all action alternatives are identified in the design features section. These BMPs protect soil and water resources by:

1) Minimizing the amount of disturbance to soils through measures such as designation of skid trails and curtailment of mechanical vegetation treatment activities during wet weather conditions

2) Preventing concentrated flow through use of drainage measures (i.e., water bars, rolling dips) on such features as temporary roads, skid trails, and firelines

3) Protecting stream courses and wetlands and drainage ways (i.e., ephemeral channels) through such means as limiting the types of activities that can occur in or adjacent to them and establishing buffers or filter strips around those water bodies designated as Aquatic Management Zones (AMZs) in which disturbance is minimized.

With implementation of applicable BMPs, most adverse effects to soils and water reources would be minimized or mitigated. Additionally, natural disturbance of soils caused by seasonal wetting and drying, freezing and thawing, and soil organism activity would naturally ameliorate some adverse effects to soils caused by the action alternatives (Radford, et.al., 2007).. Although disturbance of soils during thinning operations would be minimized through the use of BMPs, total avoidance would be neither feasible nor desirable since some amount of disturbance may be beneficial or necessary for seed bed preparation and for the establishment of herbaceous plants that may be inhibited by thick accumulations of forest litter.

Cumulative Effects

The cumulative effects to soils discussed in the No Action Alternative section would be combined with direct/indirect effects to soils of proposed vegetation treatment and recreation activities. Because the various soil disturbing activities would be distributed through time and space within the analysis area, they would not likely have an overall long term negative effect on soils. Rather, the combined effects of the past, present, and reasonably foreseeable vegetation treatments along with the treatments proposed under the various action alternatives would have long-term benefits to soils by reducing the risk to soils from an uncharacteristic wildfire, and by improving nutrient cycling through the creation of conditions favorable for return of herbaceous cover in areas where increased pine density has reduced this cover to near zero.

In addition, the proposed decommissioning of 4.19 miles of roads under the action alternatives combined with decommissioning of roads and trails under the future MEDL Recreation Planning project would have long-term benefits to soils by creating conditions favorable for the recovery of vegetation in these areas.

Water Yield

Direct and Indirect Effects

The United States Geological Survey (USGS) defines water yield as “the runoff from the drainage basin, including ground-water outflow that appears in the stream plus ground-water outflow that bypasses the gaging station and leaves the basin underground” (from: http://water.usgs.gov/wsc/glossary.html). In ungaged drainage basins, such as those that occur in the project area, annual surface runoff is frequently estimated using a water balance approach whereby surface runoff is the difference between precipitation and evapotranspiration (i.e., the combined losses of water from a system via evaporation and transpiration) plus any changes in soil moisture and groundwater storage (MacDonald and Stednick, 2003). Since forest thinning generally results in a reduction in evapotranspiration, it could, theoretically, produce a change in surface runoff. MacDonald and Stednick (2003), however, note that the large variation in the hydrologic effects of forest management activities suggest that one can find studies either supporting or refuting this hydrologic response to thinning. This variable response reflects the complex interactions of climate; topography; pre- and post-treatment forest structure, composition, and density; geology; aspect and other variables on the rainfall/runoff response. Perhaps the best summary of the runoff response to thinning in forested environments is provided by Robichaud, et.al. (2010) in which it was concluded that “no measurable increase in runoff can be expected from thinning operations that remove less than 15 percent of the forest cover or in areas with less than 18 inches (450 mm) of annual precipitation. Since evapotranspiration rapidly recovers with vegetative regrowth in partially thinned areas, any increase in runoff due to thinning operations is likely to persist for no more than 5 to 10 years.”

Studies conducted in the Beaver Creek Experimental Watershed located south of the analysis area along the Mogollon Rim at a slightly lower elevation provide local evidence for increased runoff from forest thinning. Clearcut thinning of a ponderosa pine-dominated catchment within the experimental watershed resulted in an approximately 30 percent increase in annual water yield for a period of seven years, after which water yield became statistically insignificant (Lopes, et.al. 2001). Strip thinning of a second ponderosa pine-dominated watershed with an overall basal area reduction of 57 percent resulted in only a 20 percent increase in water yield, lasting for only four years following treatment.

Under Alternatives 2 and 3 in the DLH-portion of the project area, thinning treatments are proposed in roughly 5,960 acres within the portions of Schultz Creek and Spruce Avenue drainages above Mt Elden Road and above the Forest Service boundary at Spruce Avenue Wash, respectively. These two drainage areas combined encompass roughly 6890 acres. Thinning treatments would result in an approximately 45 percent reduction in basal area within the treated portions of the watersheds or a roughly 39 percent overall reduction in basal area within the combined drainages. This reduction in forest density may be sufficient to increase the quantity of precipitation that is converted to runoff in these drainage areas depending largely on post-thinning precipitation. Based on streamflow responses to thinning in ponderosa pine drainages within the Beaver Creek watershed, the increase in water yield is likely to be ephemeral, lasting perhaps four to seven years after thinning.

Thinning treatments on approximately 3,392 acres are proposed in Alternative 4 with an estimated overall reduction in basal area of 22 percent within the combined drainages. This reduction in basal area may produce a slight ephemeral increase in water yield. Treated areas within the MM-portion of the project area are mostly within two drainage basins with outlets at Upper Lake Mary: an unnamed drainage basin encompassing roughly 4,330 acres, and Newman Canyon drainage basin, encompassing roughly 14,234 acres. The limited area of treatment within Newman Canyon Basin (approximately 1,300 acres) suggests that thinning treatments would not likely influence water yield at the Newman Canyon drainage basin scale. Since thinning would encompass a larger portion of the unnamed basin (approximately 39 percent) with an estimated overall basin-wide reduction in basal area of 18 percent, there may be a slight ephemeral increase in water yield at the drainage basin scale.

Water Quality

Whereas the direct and indirect effects of the action alternatives on soil resources are largely concerned with on-site impacts to soils that reduce productivity, the direct and indirect effects to water quality are largely concerned with the movement of sediment from hillslopes to stream courses.

The potential effects of the various action alternatives on water quality are related to the extent to which disturbance from the various treatment methods effect hillslope erosion and whether mobilized sediment would reach streamcourses. Hillslope erosion depends on such factors as amount of soil exposed, changes to infiltration rates, slope steepness, type and depth of soil, and the nature of precipitation (i.e., type and intensity) (MacDonald and Stednick, 2003). The movement of sediment from actively eroding hillslope areas to streamcourses is dependent on these same factors plus the spatial aspects of disturbance (i.e., whether disturbed areas are surrounded by relatively undisturbed areas, and the proximity of disturbance to streamcourses), and the types of post-treatment mitigation methods or BMPs that are applied.

Using Disturbed WEPP, Elliot and Robichaud (2001) compared rates of sediment yield (i.e., the amount of sediment reaching a channel from hillslope erosion) under average weather conditions for the first year following simulated ground-based mechanical thinning/yarding, prescribed fire, and wildfire conditions in a relatively dry forested ecosystem in the inter-mountain west with precipitation mostly in the form of snow (Elliot and Robichaud, 2001). *Disturbed WEPP* is an Internet-based computer program designed to predict runoff and rill/interrill erosion from undisturbed forests, forest fires (prescribed and wild), forests disturbed by timber harvesting, and rangelands under various cover conditions, and is based on Water Erosion Prediction Project (WEPP) model.

The greatest amount of erosion typically occurs in the first year following disturbance, and after several years, erosion declines to near zero. Thinning was assumed to reduce ground cover by 15 percent over a harvest unit, although this analysis did not include the road system used to accomplish thinning. This level of disturbance is, perhaps, conservatively high as evidence for total ground disturbance (i.e., disturbance as evidenced by compacted soil, rutted soil, and exposed soil) from landings, temporary roads, skid trails, and slash management was measured to be approximately 16 percent in a harvest unit thinned by ground-based mechanical harvesting on the Kaibab National Forest (MacDonald, 2013). The rate of sediment yield in the first year following simulated thinning and wildfire was predicted to be 0.03 Mg/hectare and 8.1 Mg/hectare, respectively. Predicted rates of sediment yield for simulated thinning followed by prescribed fire were approximately 0.1 Mg/hectare during the first year after disturbance.

These simulation results highlight the increase in erosion following wildfire versus that from vegetation treatment. When compared to natural rates of erosion in forest environments, which have been reported to be less than 0.1 Mg/hectare (Elliot, et.al., 1999), it can be seen that thinning or thinning combined with prescribed fire is not likely to substantially increase the amount of sediment reaching streamcoures, but that wildfire may do so by several orders of magnitude.

The BMPs that would be used to mitigate the effects of treatments are designed to:

- Minimize the amount of disturbance (e.g., requirement to designate skid trails and stream crossings, use of prescribed fire only when conditions are such that impacts to soils are minimized, etc.)
- Disconnect disturbed areas such as temporary roads, landings, and skid trails from streamcourses (e.g., designate aquatic management zones around streamcourses in which the amount of disturbance is minimized)
- Protect exposed soil through re-seeding and/or spread of slash
- Prevent the concentration of runoff on linear areas of disturbance (i.e., temporary roads, skid trails, and fire lines) through the use of such drainage features as rolling dips, water bars, and lead-out ditches.

Other methods that would be used to minimize disturbance include the use of up to 2.5 miles of existing road prisms as temporary roads, the rehabilitation of temporary roads after treatment by returning them to their pre-disturbance condition to the extent possible, and the decommissioning of up to 4.2 miles of existing roads currently designated as open to administrative use only. Because of the use of BMPs and these other methods of reducing disturbance, the amount of mobilized sediment reaching streamcourses would be minimized but not necessarily eliminated because of the nature of precipitation events in northern Arizona. In particular, the convective storms that occur during the summer months in northern Arizona may produce locally intense rainfall that drastically increases erosion in the absence of disturbance. Though rates of erosion in undisturbed forested areas of the western interior of North America are typically low, erosion rates may increase by several orders of magnitude as a function of the nature of precipitation (MacDonald and Stednick, 2003). This observation highlights the importance of the stochastic (or random) nature of erosion.

Springs, Wetlands, Riparian Areas

There are no riparian areas within the analysis area, though there are several reaches along Schultz Creek that support spatially limited facultative wetland species such as willow. Schultz Creek would be protected as an aquatic management zone with a buffer surrounding it so that no temporary roads, landings, or skid trails would be constructed adjacent to this streamcourse. This would protect any facultative wetland species found along the streamcourse and minimize the amount of sediment that may be conveyed to the stream channel.

There are three mapped springs (i.e., those that have been identified on USGS topographic maps) in the analysis area including Orion Spring and an unnamed spring in the DLH-portion of the project area, and Weimer Spring in in the Mormon Mountain-portion of the project area. These springs are not supported by discharge from the regional aquifer, which is located several thousand feet below the earth's surface in the analysis area, but are supported by perched water bearing zones that may be seasonally dry or drier for longer periods in response to extended drought periods. It is possible that thinning treatments may enhance discharge at these springs to the extent that recharge of the perched water-bearing zones that support spring flow could be increased by reduced evapotranspiration. Since there is no long-term record of discharge from these springs, it is not clear how changes in forest density over time may have affected these springs, nor is it possible to predict how thinning treatments would affect spring discharge into the future.

The only mapped wetland in the project area is shown in Figure 11. Ground-based thinning treatments would occur in the area surrounding this wetland under all three action alternatives. The wetland would be protected as an aquatic management zone with a buffer surrounding it so that no temporary roads, landings, or skid trails would be constructed immediately adjacent to this feature. Because of the designation of this wetland as an AMZ, it is not anticipated that there would be any impacts to this ecosystem.

Cumulative Effects

Cumulative effects to water resources are the effects of activities described in the No Action Alternative cumulative effects section combined with direct/indirect effects to water resources from proposed vegetation treatments. Cumulative effects to springs, wetlands, and riparian areas from the action alternatives and effects from past, present, and reasonably foreseeable activities are not anticipated to impact these features because of 1) the use of BMPs, 2) the absence of riparian areas within the analysis area, and 3) because of the spatial separation between activities and springs and wetlands.

The effects of past, present, and reasonably foreseeable thinning activities associated with Jack Smith Schultz, Eastside, and 4FRII projects could potentially combine with thinning activities proposed under the action alternatives to increase water yield beyond that which would potentially occur from just the proposed thinning treatments. However, thinning treatments would all have to reduce forest cover by at least 15 percent, and the timing of treatments would have to be such that they occurred within the same catchments during the same 4 to 7 year period (Robichaud, et.al.2010).

Cumulative effects to water quality are not anticipated to be significant because of the dispersed nature, both in time and space, of ground-disturbing activities. Though there are likely to be short-term disturbances to forest soils with subsequent increases in sediment delivery to streamcourses, not all the cumulative increase in sediment delivery would occur during the same year and within the same streamcourse. The use of BMPs and proposed decommissioning of roads common to all past, present, proposed, and reasonably foreseeable future projects would limit disturbance to soils and the potential increase in sediment delivery to streamcourses. The combined effects of past, present, proposed, and reasonably foreseeable future vegetation treatment projects would be to reduce the risk of uncharacteristic wildfires in the affected environment catchments, thereby reducing potential threats to water quality in water bodies such as Upper Lake Mary.

Alternative 2 – Proposed Action with Cable Logging on Steep Slopes

The various treatment methods proposed under Alternative 2 include prescribed fire (burn only), hand thinning with no yarding, ground-based mechanized thinning and yarding on slopes less than 40 percent, mechanized or hand thinning with cable yarding, and mechanized thinning with no yarding. The effects to soils and water resources from prescribed fire, hand thinning with no yarding, and ground-based mechanized thinning and yarding on slopes less than 40 percent were previously described in the section titled "Effects Common to all Action Alternatives" and so are not included in the discussion below.

Two different methods of cable yarding are proposed under this alternative: skyline yarding and excaliner yarding. Skyline yarding uses a system of cables to drag one end of logs or whole trees from the cutting unit to a roadside landing. In this way, logs or whole trees are partially suspended, which decreases the amount of disturbance that might otherwise occur if both ends of the log or whole tree remained on the ground. It is used on sites that are too steep for ground-based operations. A skyline yarder remains stationary on a road and supplies the power to operate the cables that pull in the harvested stems. A skyline is strung from the yarder and anchored to a tailhold at the bottom of the cutting unit. Roughly parallel "corridors" for the skyline would need to be placed every 100 to 140 feet. These corridors would be approximately 12-feet wide. Logs would be laterally yarded to this corridor and then hauled up the skyline to the landing. Skyline yarding is not limited by slope. If whole trees are yarded to the landing, a processor can manufacture the stem into logs just as in conventional ground-based operations. A variation of skyline yarding involves a machine referred to as an excaliner. Excaliners are excavators that have been converted for use as a skyline yarder but are more versatile than skyline yarders since they can be driven off-road, potentially allowing access to areas where roads could not be constructed. Yarded timber is then skidded from the excaliner to a roadside landing typically using conventional ground-based rubber-tired skidders.

The types of disturbance to soils from cable yarding are the same as those for ground-based mechanized harvesting but the magnitude of disturbance in terms of the area with visible soil disturbance, such as exposed soil and rutting, would be less than ground-based harvesting/yarding (Reeves, et.al., 2011). In a study comparing the extent of soil disturbance associated with ground-based yarding, cable yarding, and helicopter yarding, Reeves, et.al. (2011) found that ground-based yarding produced the most soil disturbance (roughly 8.2 percent of harvested area excluding roads) with cable yarding next (roughly 3.8 percent of harvested area excluding roads) followed by helicopter yarding (roughly 0.2 percent of harvested area excluding roads).

Alternative 3 – Proposed Action without Cable Logging

The treatments proposed in Alternative 3 are identical to those proposed in Alternative 2 except that helicopter yarding would replace cable yarding on approximately 973 acres and ground-based mechanized harvesting and yarding with specialized steep-slope equipment would occur on approximately 273 acres with slopes greater than 40 percent. Because helicopter yarding involves the transport of fully suspended logs to landings, there is no need for skid trails and cable corridors and less need for temporary roads. This means that the extent of soil disturbance under this alternative compared to alternative 2 would be less and potential impacts to water resources would be less.

The proposed thinning by mechanized harvesting and yarding on slopes greater than 40 percent would likely be done either with multi-wheeled harvesters or track mounted levelling feller-bunchers designed for operation on steep slopes. Yarding would be done by use of self-propelled forwarders requiring a separate entry for yarding or with harwarders (harvester and forwarder combined). In a study of the effects of harvesting on intermediate (10 to 25 percent) and steep slopes (26 to 43 percent), the overall amount of disturbance as a percentage of the harvested area was similar between slope classes, but the magnitude of disturbance expressed as amount of bare mineral soil exposed was greater in the steeper slope class (Cram, et.al., 2007). It was noted that disturbance was light to moderate, indicating less than nine percent exposure of bare mineral soil, when the harwarder traveled downslope but the amount of disturbance increased with uphill travel with areas of heavy disturbance (i.e., greater than 70 percent exposure of bare mineral soil) producing higher rates of runoff and erosion as determined through rainfall simulation experiments. There was no difference between rates of erosion in areas with no disturbance versus areas with light to moderate disturbance. This finding is consistent with research suggesting that erosion rates can be held to acceptably low rates when exposure of bare soil is less than 30 percent (MacDonald and Stednick, 2003). Disturbance associated with felling, delimbing, and bucking of logs was noted to be negligible.

Implementation of this alternative would require an amendment to the Forest Plan since ground-based thinning treatments on slopes exceeding a 40 percent gradient is currently prohibited. Through use of BMPs, it is anticipated that disturbance would be light to moderate on these slopes (i.e., no more than nine percent exposure of bare mineral soil), similar to the level of disturbance from ground-based thinning on slopes less than 40 percent

Alternative 4 – Minimal Treatment Approach

In Alternative 4, thinning treatments would be done using ground-based mechanized harvesting and yarding on slopes generally less than 40 percent. There would be fewer disturbances to soils and, subsequently, less delivery of sediment to streamcourses from implementation of this alternative; however, it would not likely provide the same level of protection against the potential impacts to soils and water resources from an uncharacteristic wildfire since it would involve treating a smaller area.

Compliance with Forest Plan and Other Relevant Laws, Regulations, Policies and Plans

Implementation of a proposed amendment to the Forest Plan to allow mechanical treatments in MSO PACs beyond 9 inches dbh, treatments in MSO restricted habitat above 24 inches dbh, and treatments and prescribed burning within MSO nest/cores would result in improved vegetative ground cover over the long term by providing conditions conducive to the establishment of a more vigorous understory of grasses, forbs and shrubs. This increased vegetative ground cover would improve nutrient cycling and soil stability while reducing the risks to soils, water quality, and watershed function from the effects of a high severity fire. Proposed population and habitat monitoring would not pose a risk to soil, watershed function, and water quality.

Implementation of a proposed amendment to allow mechanical harvesting on slopes greater than 40 percent within the project area would facilitate thinning within the project area ultimately resulting in improved soil functioning and reducing the threat posed by a high severity fire to water quality, soil productivity and watershed function. Since the Forest Plan was written and amended, mechanized ground-based equipment has progressed to be able to operate on steep slopes without adverse impacts to soil resources.

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Table 10: Compliance with Forest Plan and Other Relevant Laws, Regulations, Policies and Plans

MANAGEMENT AREAS (MA)	DESCRIPTION	Standards and Guidelines	FLMP page
Forest-wide	Forest-wide	Use Best Management Practices to reduce nonpoint source pollution	Amendment 3, replacement page 71
Forest-wide	Forest-wide	Plan for appropriate filter strips adjacent to streamcourses and/or riparian areas	Amendment 3, replacement page 71
Forest-wide	Forest-wide	Designate streamcourses and riparian areas to receive protection during projects	Amendment 3, replacement page 72
Forest-wide	Forest-wide	Maintain current satisfactory watershed conditions and improve unsatisfactory conditions to satisfactory by the year 2020.	Page 74
Forest-wide	Forest-wide	Plan projects, parts of projects, and/or management practices for soil and water resources improvement where watershed condition is unsatisfactory. Incorporate plans for soil and water improvements into project planning for other resources	Amendment 3, replacement page 72
3	Ponderosa Pine and Mixed Conifer less than 40% slopes	Identify each terrestrial ecosystem and assess soil properties to determine: Erosion hazard and on-site soil loss - Soils with a potential erosion hazard rating of severe will require specific resource management activities in order to avoid severe impairment of soil productivity.	Amendment 17, replacement page 120 Forest Plan p 146
3	Ponderosa Pine and Mixed Conifer less than 40% slopes	For each timber sale area, identify each terrestrial ecosystem and assess soil properties to determine: • Soils with severe potential for sheet and gully erosion, such as steep slopes, cinder cones, alluvial bottoms, and swales, that require specific resource management activities in order to avoid severe impairment of soil productivity. • Soil limitations for site preparation - Identify soils that present severe limitations for successful site preparation such as soils with severe erosion hazard and shallow soils. Require specific resource management activities where successful site preparation	Amendment 1, replacement page 136

MANAGEMENT AREAS (MA)	DESCRIPTION	Standards and Guidelines	FLMP page
		is limited by environmental factors in the terrestrial ecosystem. • Soil potential for reforestation - Identify soils that are suitable or unsuitable for successful reforestation. Adjust stocking levels and require specific resource management activities where successful reforestation is limited by environmental factors in the terrestrial ecosystem. • Whether soils are suitable, unsuitable, or unproductive for timber management. • Soil limitations for timber harvest activities. • Soils with high potential to convert to another vegetative type such as oak, locust, or juniper as a result of timber management activities - Modify timber management activities in these terrestrial ecosystems conversion by approved chemical or mechanical means or by prescribed fire.	
3	Ponderosa Pine and Mixed Conifer less than 40% slopes	Where open meadows in the pine/mixed conifer type are to be maintained, eliminate invading overstory vegetation, stabilize gullies to raise the water table, scarify the soil, and seed with appropriate grass and forage species. Control livestock grazing through management and/or fencing to establish the revegetation.	Amendment 17, replacement page 120
3	Ponderosa Pine and Mixed Conifer less than 40% slopes	Avoid or designate stream course crossings for skid trails. Limit to the minimum needed. Choose crossings with stable conditions or stable bed and bank material such as cobble or rock.	Amendment 1, replacement page 136
3	Ponderosa Pine and Mixed Conifer less than 40% slopes	Restrict skidding and hauling to soil moisture conditions that do not cause excessive soil compaction, displacement, or puddling.	Amendment 1, replacement page 136
9	Mountain Grassland	Manage mountain grasslands to achieve 90 percent of potential ground cover to prevent accelerated surface erosion and gully formation. Areas that presently do not meet these standards are scarified and seeded to bring ground cover to the desired level by the second decade. Restricting livestock may be	Forest Plan, P 160

MANAGEMENT AREAS (MA)	DESCRIPTION	Standards and Guidelines	FLMP page
		necessary until revegetation.	
9	Mountain Grassland	Identify each terrestrial ecosystem and assess soil properties to determine: Soil potential for revegetation - Identify soils that are suitable or unsuitable for successful revegetation, erosion hazard, and on-site soil loss. Soils with a potential erosion hazard rating of severe will require specific resource management activities in order to avoid severe impairment of soil productivity.	Forest Plan, P 160

Design Features and Mitigation Measures

Resource protection measures referred to as best management practices (BMPs) are implemented to protect soils and minimize nonpoint source pollution as outlined in the intergovernmental agreement between the Arizona Department of Environmental Quality and the Southwest Region (Region 3) of the Forest Service (ADEQ, 2008). Similar to the heirarchical approach to solid waste management of reduce, reuse, and recycle, best management practices include those which minimize or reduce the amount of disturbance, and provide methods for mitigating the effects of disturbance to soil and water resources. These resource protection measures are derived mainly from the Soil and Watershed Conservation Practices Handbook (USDA, 1990) and the National Best Management Practices for Water Quality Management on National Forest System Lands, Volume 1: National Core BMP Technical Guide (USDA, 2012). BMPs would be incorporated in prescribed fire burn plans, timber sale layouts, and timber harvesting contracts.

Table 11: Prescribed Fire Resource Protection Measures Required for the Proposed Action

Mitigation	Why

Mitigation	Why
Incorporate prescription elements into the prescribed fire plan including such factors as weather, slope, aspect, soils, fuel type and amount, and fuel moisture in order to minimize high soil burn severity.	Minimize disturbance to soils that could lead to accelerated erosion.
There are no perennial water bodies or riparian areas within the analysis area. Those stream channels that support seasonal flow in response to snowmelt and/or seasonal fluctuations in the water table would be designated as AMZs as would the only mapped wetland in the analysis area. Equipment/vehicle staging areas, and fuel used for ignition devices would be located outside of AMZs. Ignition of fuels would not be initiated within AMZs. Hand piling and burning of slash within AMZs would be avoided to the extent practicable.	Minimize the transport of sediment and/or ash to stream channels by providing areas of minimal disturbance to dissipate flow energy and encourage sedimentation.
Containment lines would be sited and constructed in a manner that minimizes erosion and prevents runoff from directly entering waterbodies by consideration of placement relative to the waterbody(ies) and lay-of-the-land and through construction and maintenance of suitable drainage features such as water bars. Where applicable, natural fire breaks such as outcrops would be used in lieu of ground-disturbing containment lines. In general, drainage features would be placed on slopes every six vertical feet starting from the base of the slope.	Minimize concentrated flow.

Mitigation	Why
Containment lines would be rehabilitated by rolling back the soil berm formed during line construction and constructing drainage features as necessary to prevent concentration of runoff. Disguise containment lines to line of sight or first 300 feet, whichever is greater, from where they intersect trails or roads using native materials such as rocks and slash.	Minimize soil detachment and sediment transport; maintain water quality.
Staging areas would be kept as small as possible while allowing for safe and efficient operation.	Minimize sediment delivery into drainages and maintain water quality.

Timber Harvesting Resource Protection Measures Required for the Proposed Action

Mitigation	Why
There are no perennial water bodies or riparian areas within the analysis area. Those stream channels that support seasonal flow in response to snowmelt and/or seasonal fluctuations in the water table would be designated as AMZs as would the only mapped wetland in the analysis area. The following activities would prohibited in AMZs: main skid trails, cable yarding corridors, new temporary roads (except at designated crossings), landings, and machine piling of slash. Crossing of AMZs by temporary roads, main skid trails, or cable corridors would be done at designated locations as approved by the timber sale administrator. Temporary road or skid trail crossings of streamcourses would be oriented perpendicular to the streamcourse.	Minimize sediment and/or ash delivery into drainages and maintain water quality.

Mitigation	Why
All fueling/servicing of vehicles would be conducted in a designated staging area(s) outside of AMZs. Temporary fuel storage tanks would be permitted and installed in accordance with the Office of the State Fire Marshall requirements.	Minimize oil spills to the environment and maintain water quality.
Prior to conducting harvesting activities, all skid trails, cable yarding corridors, temporary roads, and landings would be designated on a map and visibly marked by means of flagging or other suitable measures for approval by the timber sale administrator.	Minimize soil disturbance, prevent concentration of runoff, and minimize delivery of sediment to stream courses.
Skid trail design would not include long, straight downhill segments which would concentrate runoff. Cable yarding corridors would be located to efficiently yard materials with the least soil damage. Skid trails and cable yarding corridors (unless logs are fully suspended) would be located out of AMZs except at approved crossings. Skidding or cable yarding up or down drainage courses would not be permissible unless, in the case of cable yarding, logs are fully suspended.	Minimize erosion and maintain water quality.
Insofar as safety permits, trees would be felled to angle in the direction of skidding.	Minimize soil disturbance and compaction.
Drainage of roads would be controlled by a variety of methods to prevent the concentration of runoff including but not limited to insloping of the road bed toward an interior drainage ditch with periodic cross drains, outsloping of the road bed, crowning of the road bed, and construction of rolling dips and turn-outs. Drainage from landings and skid trails would controlled to prevent concentration of runoff by installation of appropriate drainage features and/or placement of slash.	Minimize soil erosion and maintain water quality.
Equipment would not be operated when ground conditions were such that detrimental soil disturbance, defined as a 15% increase in soil bulk density and wheel ruts of 2” or	Minimize soil compaction. .

Mitigation	Why
greater, would occur as determined through monitoring of such indicators as depth of soil rutting.	
Machine piling of logging slash would be done in such a manner as to minimize the construction of new clearings for slash piles through use of natural openings, temporary roads, and landings. Slash would not be machine piled within AMZs or drainage channels not otherwise designated as AMZs.	Minimize amount of soil disturbance.
Skid trails and cable yarding corridors would be rehabilitated after use by a combination of any or all of the following practices in order to prevent the concentration of runoff and to protect exposed soil : reshaping the surface to promote dispersed drainage (i.e., create convex vs. concave cross-section), installation of drainage features such as water bars to shed water, and spreading slash across skid trails and cable yarding corridors to protect areas where mineral soil is exposed. Where skid trails and or cable yarding corridors intersect existing roads or trails, native materials such as logs, slash, and/or boulders shall be placed along skid trail or cable corridor to line-of-sight or first 300', whichever is greater.	Minimize soil erosion and maintain water quality.
Temporary roads and landings would be rehabilitated after use by a combination of any or all of the following practices in order restore original topography, protect soils, and prevent concentrated runoff: roll berms created during temporary road and/or landing construction back across the disturbed surface to restore original surface topography to the extent practicable, install drainage features such as water bars where needed to prevent runoff from concentrating, and spread slash on areas with exposed mineral soil. Where temporary roads intersect existing roads or trails, native materials such as logs, slash, and/or boulders would be placed along temporary road to line-of-sight or first 300',	Minimize soil erosion and maintain water quality.

Mitigation	Why
whichever is greater. Where visual observation indicates that the above methods of erosion protection were inadequate, re-seeding would be accomplished using a certified weed-free mix of native or naturalized grasses.	

Monitoring Recommendations

Resource protection measures referred to as best management practices (BMPs) are implemented to protect soils and minimize nonpoint source pollution as outlined in the intergovernmental agreement between the Arizona Department of Environmental Quality and the Southwest Region (Region 3) of the Forest Service (ADEQ, 2013). The monitoring of the implementation and effectiveness of BMPs is part of the National Best Management Practices for Water Quality Management on National Forest System Lands, Volume 1: National Core BMP Technical Guide (USDA, 2012). National standardized sampling and monitoring protocols have been developed to facilitate monitoring of timber harvesting and prescribed fire activities. The standardized sampling and monitoring protocols are recommended to monitor vegetative treatment activities associated with the selected action alternative.

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